Water Works and Sewerage

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Construction View of Clarifier and Mixing Tanks

The New Water Works of Cedar Rapids, Ia.

Construction Features of the Combined High Lift Pumping Station and the 12,000,000-Gal. Daily Capacity Water Softening and Filtration Plant

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THE new Cedar Rapids water works consists of a low lift pumping station and intake located on the east bank of Cedar River about three miles upstream from the city and a 12,000,000 gal. daily capacity softening and filtration plant located midway between the low service station and the city, opposite the beautifully wooded Shaver Park.

General Features.—The filters and clear well, suction channel and premixing tanks are included in the high lift pumping station and are built of reinforced concrete. Concrete is also used for all the pumping station substructures and floor slabs throughout the building. The superstructure is of masonry construction, with the roofs supported on steel trusses and beams.

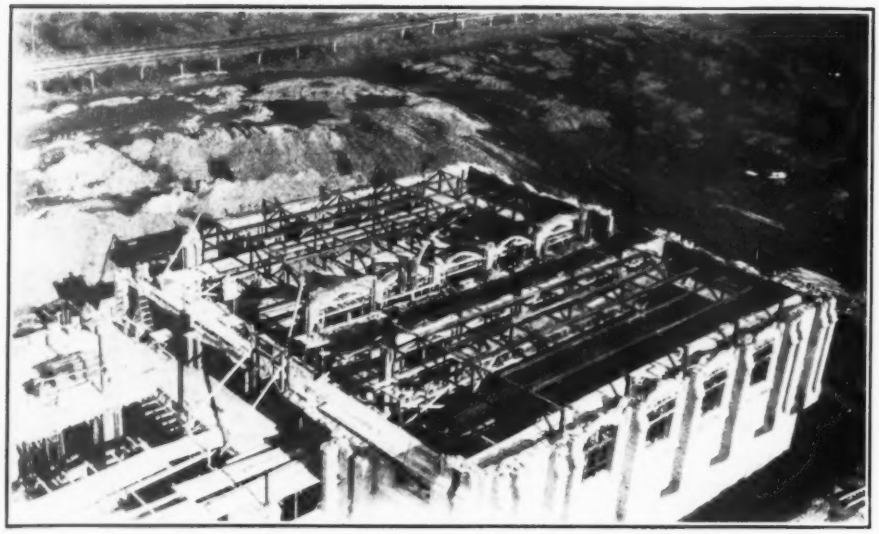
The high lift plant also includes two 50 ft. square mixing tanks 22.5 ft. deep, two clarifier tanks 100 ft. square with a saucer shaped bottom giving a depth of 16.5 ft. at the walls and 19.8 ft. in the center, and a carbonating tank 40 feet square and 16.5 ft. deep. These tanks are also of reinforced concrete construction.

The outside of the tanks will be backfilled with earth to within 1 ft. of the top of the tanks and at this level there is a berm 5 ft. wide. From this level the earth fill slopes down to grade with a slope of 1½:1. Earth fill will be carried around most of the pumping station building also.

A permanent siding from the C. R. I. & P. R. R. is a part of the new water plant and this was built prior to the general contractor starting construction work. It is needless to say that this track and the area adjacent to same has played an important part during the construction since all materials may be delivered right to the job in cars.

The Theodore Stark Construction Co., Inc., of Cedar Rapids, Iowa, was awarded the general contract for the job and with J. C. Gilbert as superintendent, work was started July 29, 1929.

Excavation.—At that time excavation for the clear wells was started and for this work a Speeder gasoline operated ¾ cu. yd. dragline outfit was used. The material encountered included loam, sandy clay and sand. The average depth of excavation for the clear wells was 15 ft. With the use of the dragline this excavation was done from outside the excavation proper and the earth loaded into trucks or 5 cu. yd. wagons to be delivered to the



Filter End of Building on Dec. 27, 1929

various spoil banks for use later as backfill.

The excavation for the pumping station building totaled 8,500 cu. yd. and the footing levels for the various units of the building varied quite extensively. However, the major portion of the excavation for the building was concentrated in the filter and clear well end of the building, the yardage here being 5,000 cu. yd. For the suction channel along the south side of the pump room a cut of 18 ft. is necessary whereas for the pump room proper, the cut was only 4 ft. Adjoining the pump room are the pre-mixing and CO_2 generator rooms, the excavation for these being 5 ft. and 13.5 ft., respectively.

A number of pipe trenches cross the pump room. These are about 5 ft. deep and vary in width from 4 to 6.5 ft. These cuts were made vertical and no caving of the sides of the excavation occurred, this permitting the use of the bank as the outside form for the concrete of the pipe trenches.

All final or finish grading was done by hand, but since the dragline work had been finished close to grade, the final grading was not a very big item.

Excavation for the building was of such a character that with cuts up to 18 ft. in depth, and only a slight slope of the sides of the excavation, little if any shoring was required. This helped speed up the work materially.

The excavation for the tanks totaled 7,400 cu. yd. and aside from the saucer shape bottom of the clarifier tanks, there was nothing of particular note to record about this work. The depth of cuts ranged from 1 to 15 ft. in depth, however. As in the pumping station excavation, the final grading was done by hand, insuring an even bearing surface right to grade.

Concrete Mixing Plant.—All reinforced concrete for the job was 1:2:4 mix to which was added 3 lb. of Celite per bag of cement. Hawkeye Portland Cement was used and the aggregates were river sand and crushed stone from quarries at Glory, Ia.

The concrete mixing plant was located adjacent to the siding track and between the pumping station building and the tanks. The plant consisted of a cement shed with a capacity of 3,500 bags of cement, 100 ft. high wood tower for chute distribution of concrete, elevated steel aggregate bins, and a 2-bag Koering mixer. The steel bins were equipped with Butler measuring hoppers and discharged into the mixer. The mixer was equipped with an accurate water measuring device which controlled the water for the concrete mix.

All aggregate was delivered to the job in cars and unloaded by a Speeder gasoline operated outfit using a ½ cu. yd. bucket. The storage piles for the sand and crushed stone were adjacent to the bins but since material could be received on rather short notice not much storage was carried. The schedule of shipping was so arranged that material would be received during times of concreting and the materia then unloaded directly into the bin without rehandling.

Concreting Operations. — Concrete work started Aug. 29, 1929, and wa completed Dec. 23, 1929. The high lif station structures required 4,400 cu. yd of concrete and 418 tons of reinforcing steel. The reinforcing steel was rai steel furnished by the Laclede Stee Co. of St. Louis, Mo. The bars were all bent to proper shape at the mil after the reinforcing details had been checked by the resident engineer on the job.

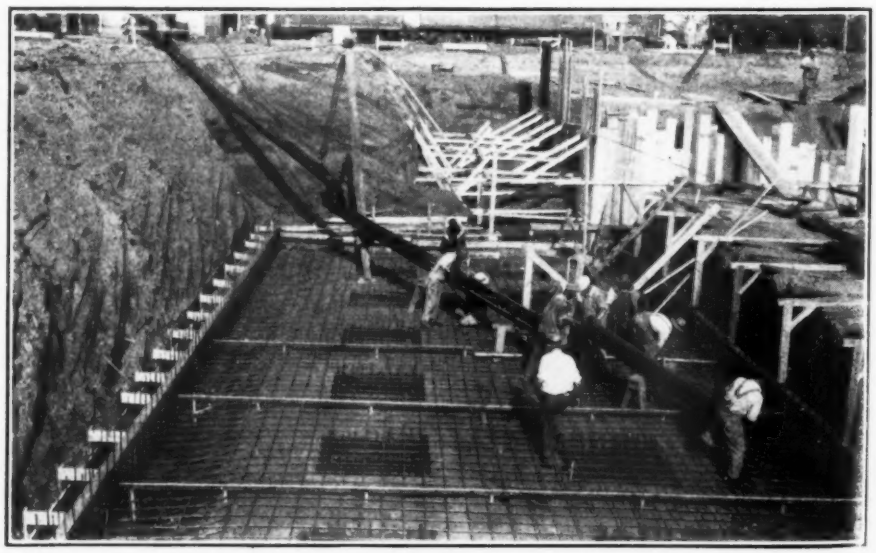
The first concrete poured was for the floors of the clear well and from then on concreting alternated between the pumping station building and the tanks. The concrete was quite evenly divided between the building and the tanks and totaled 2,226 cu. yd. for the tanks and 2,174 cu. yd. for the building.

Concrete was distributed from the tower to receiving hoppers and buggies were then used to further distribute same. The mixing plant functioned without a hitch throughout the job and no breakdowns occurred during any pour.

The major part of all the concrete is required to be water tight and special care was taken to spade all concrete thoroughly and good keyways were made at all joints. All exposed concrete is carborundum rubbed finish and for this purpose No. 24 Carborundum stones were used and the rubbing done by hand. In summer the forms were stripped 24 hours after the concrete had been placed and the rubbing done while the concrete was still somewhat green. The concrete walls throughout the job are excellent and all connected with the work are proud of the result.

The concrete yardage during the construction months was as follows:

	Cu. Yd.
August (2 days)	220
September	859
October	1,879
November	1,019
December	443



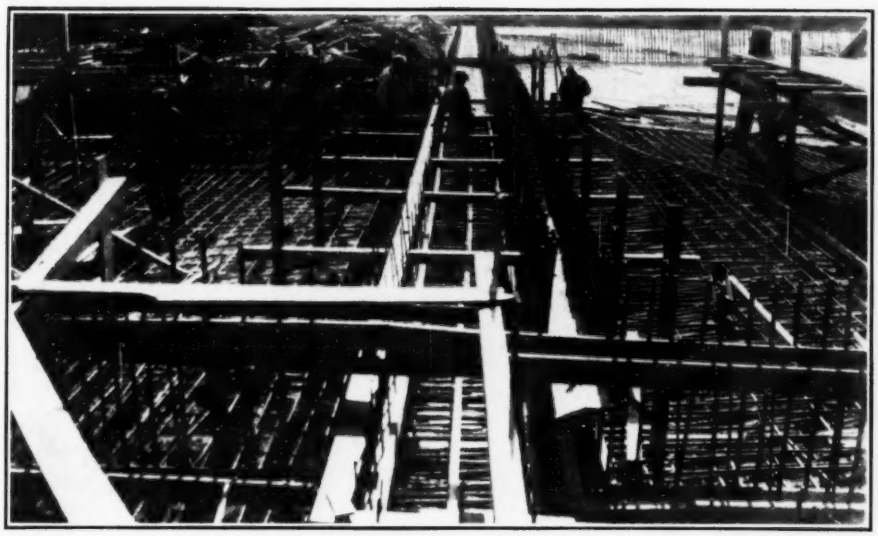
South Half of Clear Well, on Aug. 26, 1929

Cold Weather Concreting. — Some concrete was placed during freezing weather but concreting was never started with the temperature below 20° F. The concrete pours were also made smaller during cold working days so that all concrete would be placed during the day when the temperature would usually range somewhat higher than at night. Also during cold weather all aggregates would be heated by steam and warm water used in the mix, and should there be frost on the forms and steel a steam jet would be kept just ahead of the concrete to break up same. At the finish of any pour it would be canvassed in and salamanders kept burning until the concrete had set and no concrete was damaged at any time due to freezing.

Exceptionally good weather has prevailed since the start of the job and up to the present time the job has only been shut down four days on account of severe cold weather and two days due to rain. During this time, however, material was unloaded from cars making the time lost negligible.

The Form Work.—Lumber for formwork was delivered to the job in carload lots and stored along the track until needed. For the wall and slab forms panels were used and on the average these forms were used five times and are still in very good condition. These panels are built of 1x6 sheating, 2 ft. wide and held 2 ft. on centers with 1x4 wood cleats and are built in two lengths, 10 ft. and 14 ft. Prior to using they were oiled with parafine oil and after each stripping cleaned and oiled.

The studding for the form work was 4x4 dressed lumber and was spaced 2 ft. on centers. This spacing of the studding gave support to the panels, 1 ft. on centers, since the cleats on the panels are also 2 ft. spacing. This type or method of formwork gave a very rigid and easily erected form and one which was easily stripped also. The walers were built of two 2x6 members spaced ½ in. apart, permitting a ⅜ in. rod to pass between them. The form clamps used for all forms was the Universal clamp in conjunction with ⅜ in. tie rods.



Reinforcing Steel Layout at Tank

For supporting the various floor slab forms and cantilever projections of the tanks, adjustable shores were used and about 1,500 were in use during the concreting.

The pumping station concrete near the grade line was quite an intricate piece of formwork. At this level most of the walls are bracketed for brick work and with pilasters and areaways also to be formed at this level quite considerable time for formwork was necessary.

The walls for the tanks are cantilever type with the inside wall line being plumb and the batter in the walls being on the outside. Around the clarifier tanks there is a concrete cantilever projection for the support of the traction rail of the clarifier equipment and the influent and effluent troughs are also cantilevered out from the wall. The above concrete required a little more difficult forming than for the walls but there was nothing of particular note with regards to same.

The Exterior.—The exterior walls above grade of the pumping stations are faced with "Slag-Brix" manufactured by the Silica Brick & Eng. Co. of Chicago. All interior walls are of common brick manufactured by the Purington Paving Brick Co., Galesburg, Ill.

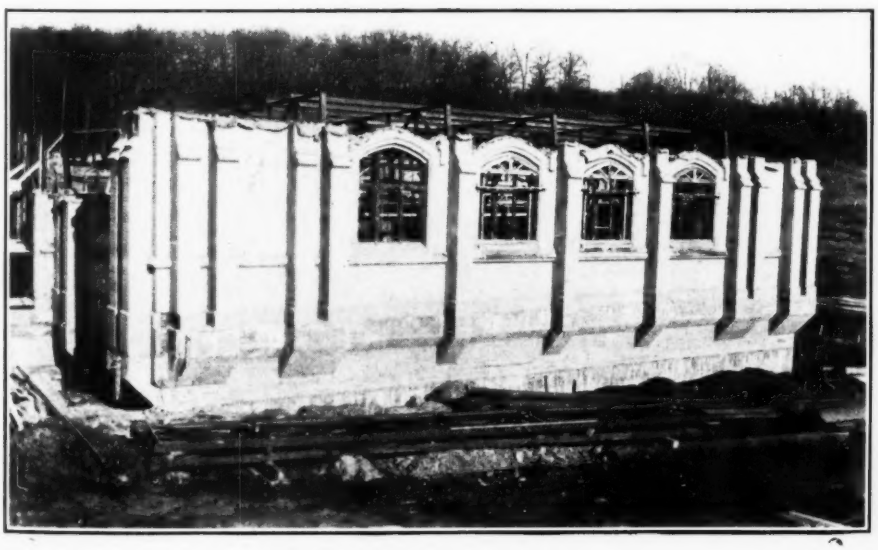
The stone base course and all trim is of artificial stone manufactured by the Chicago Architectural Stone Co., Chicago, Ill.

The mortar used for all brickwork is a portland cement mortar which matches the color of the face brick. The face brick joints are struck flush with every sixth course struck with a "V" joint giving the building a stone appearance. Care was taken to insure a match between the face brick and the stone and good results have been obtained.

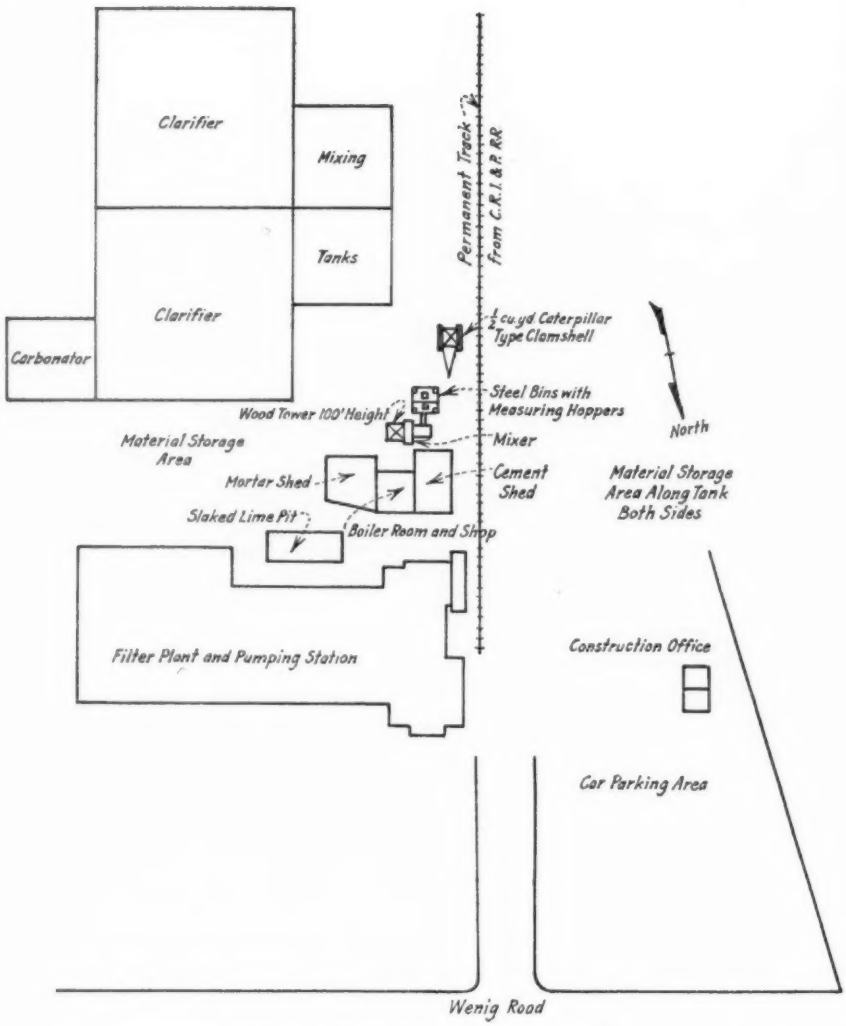
For the pumping station building, 190 M face brick and 690 M common brick and 7,000 cu. ft. of cast stone are required. At the present time the brick work is approximately 13 per cent completed and this work was started in December. The contractor figures on working the bricklayers throughout the winter months on all days that the weather permits.

The mortar for the brickwork is mixed by a mechanical mortar mixer located in an enclosed and heated mortar shed. The sand is delivered at this time in trucks directly into the shed and during cold weather the sand is kept warm with steam. The brick after unloading from cars is covered and protected from the elements insuring dry brick for the work. The cast stone is shipped from Chicago and packed in excelsior and reaches the job in good condition.

The filter end of the building is practically completed as to brickwork and with this part of the building



South Side Filter End of Building on Dec., 27, 1929



Sketch Showing Layout of Construction Plant

finished the filter equipment contractor will be able to start work.

The filter equipment will be furnished and installed by the International Filter Co. of Chicago. Their materials have reached the job and it is expected to start this work in January.

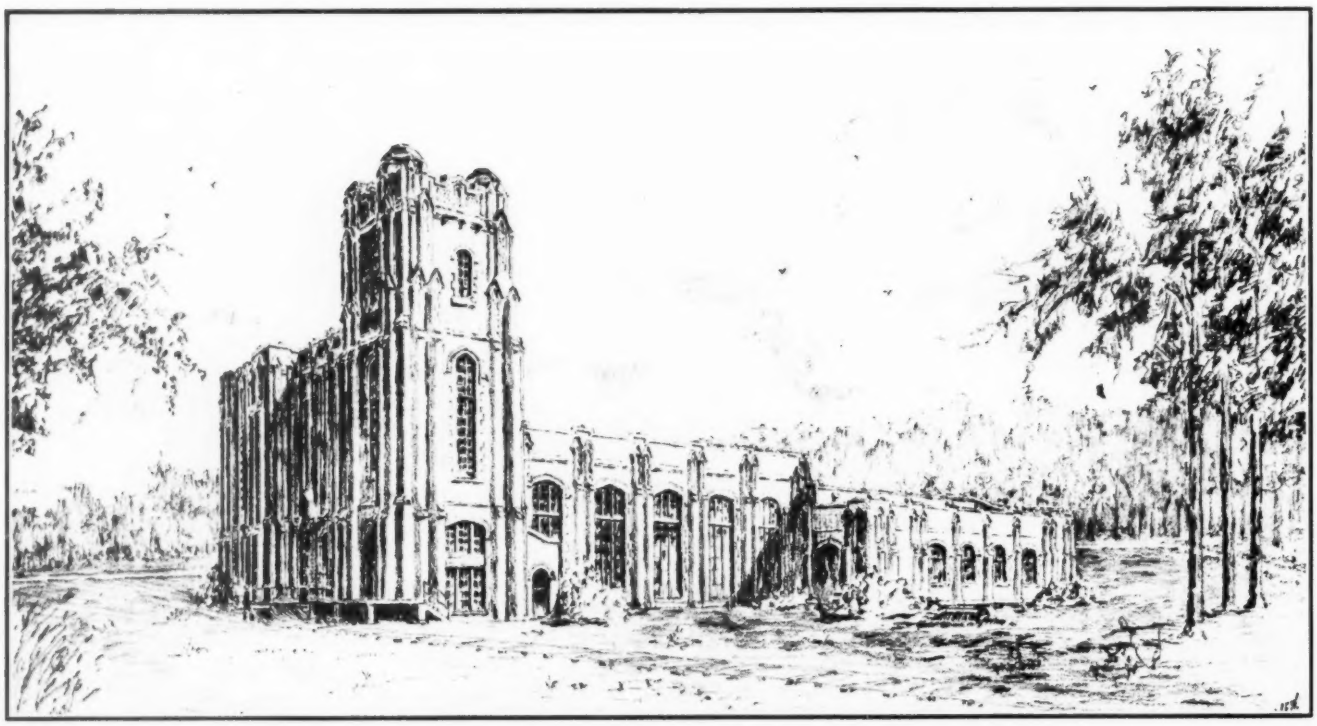
The steel trusses at the filter end of the building have been set and also the structural steel columns and framing for the support of the wash water tank. The structural steel is furnished by the Iowa Steel & Iron Works of Cedar Rapids.

Ornamental iron for the job is manufactured by the C. W. Olson Manufacturing Co., Minneapolis, Minn.

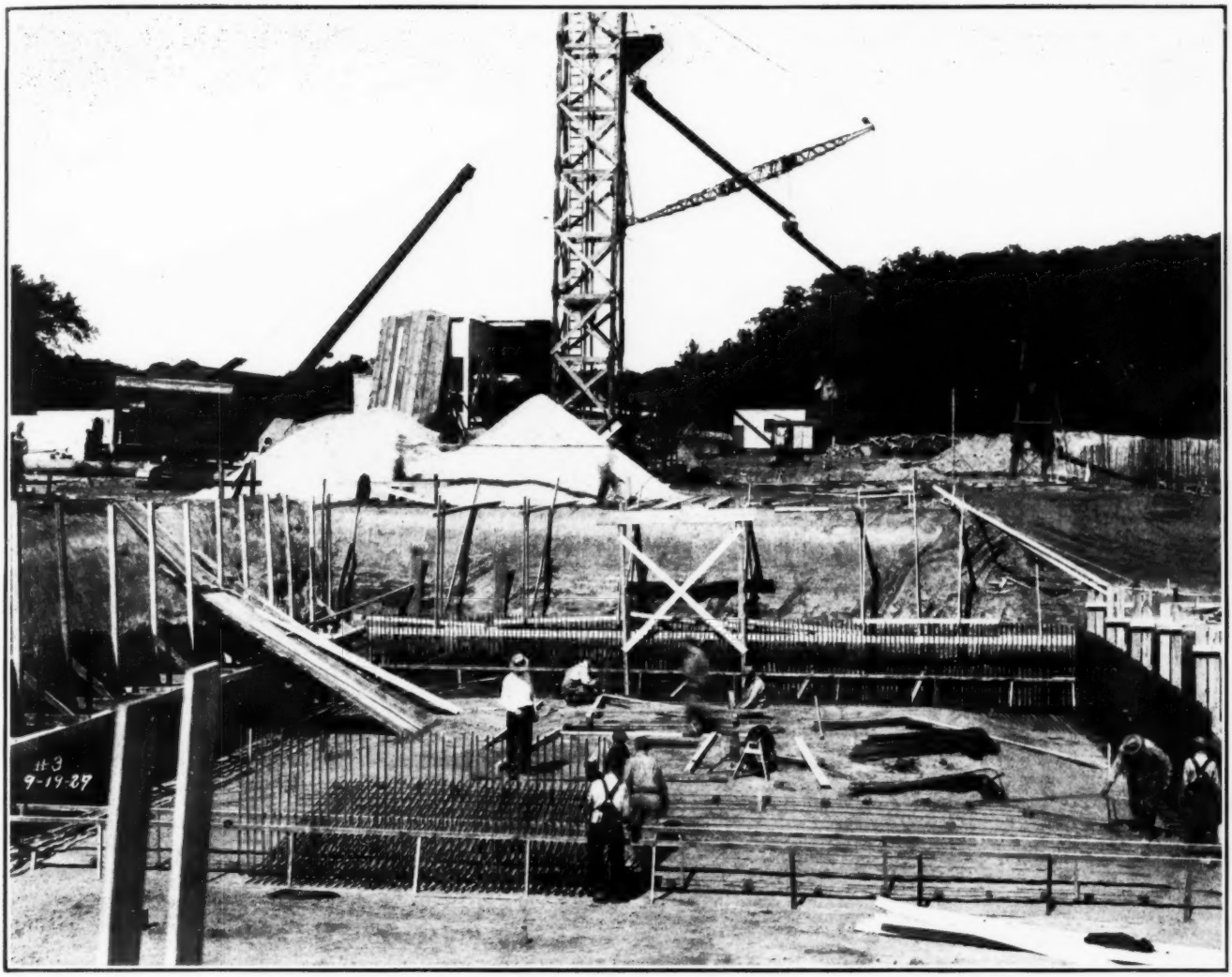
A Dorr clarifier unit is being installed in the south clarifier tank.

The pumps and all equipment for the new water plant are electrically operated and the low lift or intake station is operated by remote control. This plant arrangement requires the installation of considerable electrical equipment and this work is being done for the general contractor by the H. J. Robertson Electric Co. of Cedar Rapids, Ia.

Piping.—For the station and yard piping cast iron pipe is being used, the size varying from 54 in. down to 6 in. Excluding the pipe gallery piping 73 tons of flange pipe and fittings and 362 tons of bell and spigot pipe are required to complete the installation. The sewers with the exception of a section of the wash water waste sewer are of vitrified tile and 780 ft. of 36 in. vitrified tile segmental block sewer has been completed at this time. All the



Perspective Drawing of the New Pumping Station and Filtration Plant of Cedar Rapids, Ia.



Concreting Plant Showing Tower and Chuting Arrangement for Placing the Concrete

outside or yard piping is being laid by the city water works pipe laying crew. The water works crew has also completed to date a 24 in. high service main to the new plant and the 30 in. low lift header from the intake station up to the high lift station.

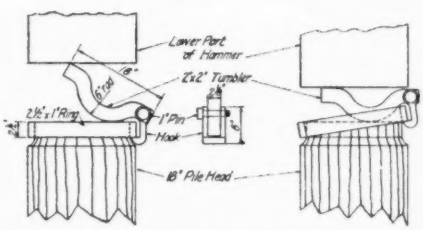
Work for the low lift or intake station has been confined to the driving of creosoted piles for the intake and the piles for the support of the pumping station building. With the concrete work completed at the high lift station the schedule is to push the work at the low lift location next.

The new water plant is scheduled for completion in July, 1930, and from the present outlook of the work it should be completed on time.

H. F. Blomquist is superintendent of the City Water Department. The new plant was designed by Alvord, Burdick & Howson, engineers, Chicago, who associated with them V. A. Matteson on architectural and Chas. P. Hoover on chemical features. The supervision of the construction is under the engineers who are represented on the job by H. T. Rudgal, resident engineer.

Simplifying the Removal of Head-Rings from Driven Piles

A useful device is the hook-and-tumbler arrangement shown in the accompanying illustration, used for removing head-rings from driven piles. The rings which are slipped over the heads of wooden piles while driving, to prevent splitting or "brooming," are used again and again, and accordingly a band must be removed once a pile has been driven. The blows of the pile-driver hammer result in wedging the pile head into the ring very tightly, and removal of the ring with ordinary tools such as hammers and bars is difficult.



Left—Device in Place with Tumbler on Top of Pile, Hook Under Ring and Hammer Falling. Right—A 6-In. Drop of the Pile-Driver Hammer Has Raised the Ring. Another Elevation of the Hook Is Shown in the Center

The sketch shows the action of the device clearly. When the pile has been driven, the tumbler or lever is placed on the top of the pile and the hook is caught under the ring. The hammer of the pile driver is now allowed to drop about 6 in., with the result that the ring is usually loosened a sufficient amount to allow of removal with a sledge. If the ring is still tightly wedged, the tumbler may be reversed and the hook caught under the opposite side of the ring. A second blow of the pile-driver hammer will free the ring.

This device will save labor and prevent damaging of the pile head. Even where it is necessary to cut off the heads of driven piles at a given elevation, it will be found easier to remove the rings by this method before sawing off the heads than to split the cut-offs to free the rings. The sizes of the parts may be altered to suit conditions, but the dimensions shown will be found convenient for most work.

Chlorination an Integral Part of Purification

THE following constitutes a digest of the report of H. W. Streeter, chairman, Committee on Water Purification and Treatment as presented to The Conference of State Sanitary Engineers in meeting at Minneapolis, Minn., Sept. 28-30, 1929.

Collective Study of Chlorination Efficiency.—The opinion of the committee is based upon chlorination data collected during a survey of more than thirty representative purification plants located in various sections of the country supplemented by experimental studies, both conducted by the United States Public Health Service.

The object in view was to throw light on the much debated question as to whether chlorination in conjunction with filtration processes should be considered purely as an "external factor of safety" or as an "integral part of purification" in such processes. Further than this an attempt has been made to set up a "normal efficiency ratio" for water chlorination and to determine if possible the extent to which it might be affected by such modifying factors as temperature, time, bacterial density and the extent to which chlorine-absorbing substances are present in the water. The conclusions reached as a result of these surveys and studies are briefly the following:

a. That chlorination must be regarded as something more than a "factor of safety" and should be considered an "integral part," and an essential part of filtration plant operation, is clearly indicated.

b. Unaided by chlorination the filtration processes employed on the large majority of raw waters delivered to plants in this country cannot produce effluents conforming to the Treasury Department B. Coli Standard.

c. For river waters of the Ohio type the limiting raw water B coli index corresponding to a standard quality of filter effluent without chlorination has been found to be about 60 per 100 cc. For Great Lakes waters the maximum appears to be less than 10 per 100 cc.

Effects of Time, Temperature and Chlorine Absorbing Substances.—As regards the effects of time, temperature and chlorine absorbing substances on the efficiency of chlorination, the experimental work of the Public Health Service has indicated, broadly, the following:

a. The time required to attain a given degree of bacterial reduction appears to bear a definite relationship to the average concentration of residual chlorine in the treated water during the period of such reduction.

b. The presence of chlorine absorbing substances affects the added amounts of chlorine necessary to produce a given efficiency, but the controlling factor in such efficiency appears to be the residual chlorine content rather than the amount of chlorine applied. The chlorine absorbing substances therefore exert but an indirect effect on chlorination efficiency.*

c. The bacterial efficiency of chlorination is affected by temperature, being somewhat greater at higher temperatures.

Raw Water Prechlorination. — Another phase of chlorination which received the committee's attention is the matter of raw-water prechlorination as a preliminary stage of treatment. The results of more than a year's study of the effects of prechlorination at the Public Health Service experimental filter plant at Cincinnati has rendered possible the following statement quoted from the report:

"Both the studies recorded by Enslow† and that made by the Public Health Service have indicated a clear gain in over-all bacterial efficiency effected through the use of prechlorination. The latter series of tests showed, also, that the maximum raw water B. coli index consistent with producing a final (rechlorinated) effluent conforming to the revised Treasury Department standard could be increased from about 10,000 per 100 cc. without prechlorination to about 25,000** per 100 cc. with prechlorination. Some observations recorded by Enslow have indicated that prechlorination results in a measurable economy in coagulants and in a lengthening of filter runs. Although the Public Health Service tests failed to confirm these two observations to any well-marked extent, they gave fairly clear evidence that prechlorination, if properly controlled, may be carried on without any material deterioration in the conditions of the filtering medium and with beneficial effects in minimizing plankton growth in sedimentation basins. In general, prechlorination appears to be establishing itself rapidly as an added stage of purification in connection with rapid sand filtration, particularly in the treatment of variable and highly polluted raw waters."

*Note: The controlling effect of residual chlorine is illustrated by appended efficiency curves comparing plants maintaining concentrations of residual chlorine just inside of the taste producing limits, with plants carrying as little residual chlorine in the filtered water as could be done with reasonable safety.

**Note: The committee chairman more recently advises that this figure will probably lie between 20,000 and 25,000 per 100 cc.

†Municipal News and Water Works, August, 1928; Western Waterworks, August, 1928; Canadian Engineer, Aug. 7 and 14, 1928; Jour. A. W. W. A., December, 1928.

The Pictorial Story of a Water Works

The story of Hackensack water is told in pictures which are being publicly exhibited at the district offices of the Hackensack Water Co., of Weehawken, N. J.

"Developing Your Water Supply" is the theme of three pictures in the Englewood office which tell of clearing the land, dredging the storage basin, and the new dam and the lake at Oradell—work which required ten years to complete.

A picture in the Westwood office entitled "Purifying Your Water Supply" depicts the operating room of the filtration plant at New Milford, showing control tables of sixteen filters which are on either side of the building. All water is filtered before being pumped.

Other pictures at Westwood are styled "Safeguarding Your Water Supply." They portray the laboratory at New Milford where the river water and the filtered water are sampled several times every day and tested to insure the purity and safety of the water delivered.

At the Ridgefield Park office, "Water in Reserve" shows the service reservoir in Weehawken, where water is held to equalize pressure and to furnish emergency supply. There are three such reservoirs in the southern part of the system. A second picture at Ridgefield Park bears the title "Collecting Your Water Supply," and shows the intake canal through which all water needed is brought from the upper Hackensack River into the station at New Milford.

"Pumping Your Water Supply" is the subject of the display at the Rutherford office. The 20,000,000-gal. pump at New Milford, one of four which sends water into towns, including Union City, Secaucus, Rutherford, Rochelle Park, Hillsdale, and Northvale, is portrayed. At Rutherford also pictures of two high pressure pumps at New Milford are exhibited. These pumps deliver water to the high service mains at a pressure of 230 lb. per square inch for use along the Palisades. Their capacity is 16,000,000 gal. per day.

At the Hackensack office scenes of more than a quarter-century ago evidence the influence of science and engineering in developing the modern water supply available to the 51 towns and cities supplied by the Hackensack Water Co. in Bergen and North Hudson counties.

Two pictures inscribed "Developing Your Water Supply" delineate "The Mill Pond in 1900" and "Old Dam and Mill." The theme is Veldran's old mill at Oradell, now replaced by the new dam and lake. A third picture at the Hackensack office is that of the settling reservoir at New Milford. It illustrates the process, "Purifying Your Water Supply."

The pictures, it is pointed out, indicate not only the development of the water system but also the scientific, economic, and social advance of this territory.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

The Rapid Sand Filter Bed

IN starting the section on filtration no subject would be more appropriate for the first discussion than the filter bed itself. It is passing the water through this part of the plant that gives us the name filtration. At first the filter beds were relied upon to do practically all the work of purifying the water, except that sedimentation prior to filtration was frequently used. Where fairly good results were desired it was essential to use fine sand and slow rates of filtration. As the construction of slow sand plants increased it was found that there were many waters where good clarification could not be obtained without some kind of pretreatment, especially for the highly turbid waters.

Chemical Treatment and Rapid Sand Filtration Developed.—The inability of slow sand filters to give satisfactory results at many places led to the use of chemical treatment for coagulating the suspended particles prior to filtration. The success of this method of treatment brought about many changes in plant construction. The chief changes in the filter beds were the use of coarser sand, higher rates of filtration, and provision for washing the sand in place by reversing the flow of water through the beds instead of scraping the surface as is the practice for slow sand filters. So many things may be accomplished by chemical treatment that in many plants the filter beds now play a minor part in the purification. Since the advent of rapid sand filters very few slow sand plants have been constructed. In fact so extensively has become this type of filtration that little space in the water purification literature need be given to slow sand beds. The present discussion will deal largely with how a sand bed of the rapid sand type removes the coagulated matter from water. Details of construction, operation, and filter bed troubles will be the subjects for future discussions.

Sand Beds for Rapid Sand Plants.—The sand beds for rapid sand plants are largely standardized along the following lines: Rectangular or round beds of most any size up to 1,500 sq. ft. of filtering surface, 24 to 30 in. of sand, 0.3 to 0.5 mm. diameter for the size, of which 10 per cent of the sand is finer, graded gravel for supporting the sand, and a system of underdrains. The water is passed downward through the beds at a maximum rate of 2 to 3 gal. per square foot per minute. Two gallons per minute is usually regarded as the rated capacity, but the majority of filter beds are operated at higher rates part of the time. The sand beds are washed by forcing filtered water through them in the reverse direction of filtration at a rate sufficient to partially suspend the sand. Fifteen gallons per square foot per minute is used for the washing rate in many plants. Air, and a slower washing rate was used extensively at first, but very few plants are now constructed for the use of air.

Voids in the Sand Beds Much Larger Than the Suspended Particles. — It should be evident that the method used for washing the filters leaves the sand about as loosely packed as is possible for it to be under water. When the sand is clean there is very little shrinkage during filtration due to the loss of head increasing as the bed becomes clogged, but where the sand grains have become coated with a gelatinous coating some beds have a shrinkage of 5 per cent or more by the time the loss of head reaches its maximum. This is responsible for cracks opening up in the surface and along the sidewalls of the filters in many filtration plants.

The arrangement of the sand grains in a filter bed might be compared to gravel of fairly uniform size dumped from a truck. It is evident that the dumping does not produce the minimum void area, and there are many open spaces almost as large as the average size particle making the mass. Openings fully one-half the size of such particles will be found leading into the pile for some distance. Many particles suspended in water are less than 0.001 mm. in diameter, and it should be evident that passageways through sand grains 0.3 to 0.5 mm. in diameter are many times larger than the finer particles, even though the sand be compact to its minimum void area. It is true that sand beds will remove particles much smaller than the voids, but when the grains are several hundred times larger than the particles it is evident that this is too great a difference for the removal of all suspended matter, especially if the removal is by lodgment of the particles in the sand voids. Coagulation is essential for this type of filtration, if the water is to be made perfectly clear.

Flocculated Matter Easily Filtered.—Examination of the flocculated matter produced by aluminum hydroxide and ferric hydroxide under the microscope reveals a surface quite irregular in shape. If a microscope could be made 50 to 100 times more powerful than the greatest magnification possible today, the structure likely would be found to be porous, being composed of a meshwork of irregular shaped fibers. With a substance so greatly expanded as aluminum hydroxide or ferric hydroxide it is evident that the mass must be quite porous. The irregular shape of the coagulated particles and the ease with which they may be forced into most any shape makes them ideal for lodgment in the wedge-shaped voids where two sand grains touch each other, or for a coagulated particle to attach itself to one already lodged. Deflection of the water at nearly every sand grain is also ideal for directing the coagulated particles into the wedge-shaped areas.

The average filter bed has a depth equal to the diameter of about 1,200 sand grains 0.5 mm. in diameter. A cubic foot of this size sand compacted to its maximum density will contain nearly 200 million sand grains. It seems reasonable to expect that there is an average of more than one wedge-shaped area for each grain of sand in a position to lodge coagulated particles. This means that every particle of coagulated matter passing beneath the surface of the sand bed has hundreds of places where it may become lodged, consequently there is practically no possibility of the particles passing through the beds. This is assuming

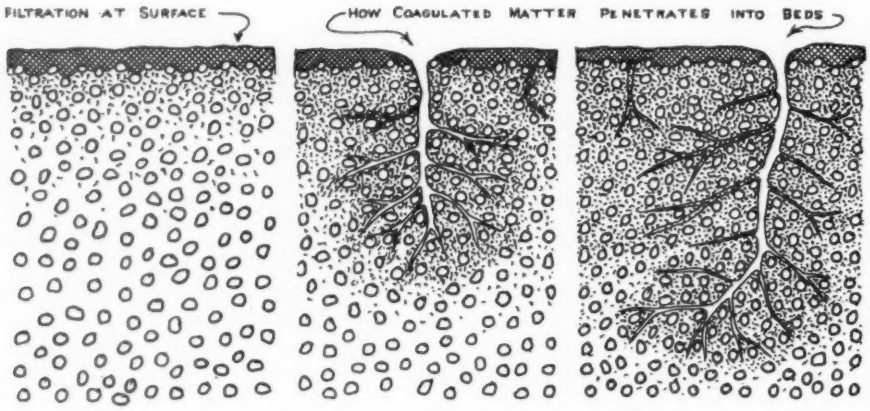


Fig. 1—Sketches Showing What Takes Place in a Filter Bed

that the bed has not channelized nearly to the bottom of the sand as will be explained later.

Filtration Is Largely by Straining and Lodgment of the Particles.—So far we have assumed that the removal of suspended particles passing the surface of the bed is by lodgment in the sand voids. It is likely that the sand grains in many filter beds have a gelatinous coating that not only aids the lodgment but it may have an attraction for the suspended matter. Some are of the opinion that these films are necessary for good turbidity removal and that the surface attraction is the main way in which the particles are removed. The writer puts little faith in this belief, for straining at the surface and lodgment beneath the surface accounts for the removal of practically all suspended matter removed by the filters. The gelatinous coating on the sand grains, however, is not a detriment providing it does not allow too much shrinkage of the beds. If it were possible to get filtering material with no attraction whatever for the coagulated matter and in which no gelatinous coating will form the turbidity removal would still be practically as effective as it now is for sand beds.

It is evident that much of the coagulated matter is removed by straining out at the surface of the sand. In fact for some waters the coagulated masses are formed so toughly there is little penetration into the beds. This is especially true where the water is not very turbid and contains many microörganisms. The mat on the surface forms so toughly it is not broken as the loss of head increases. Most of the coagulated matter that gets below the surface under this condition gets there before the mat forms tightly over the filter surface. This gives short filter runs, and the loss of head keeps increasing at an accelerated rate; that is, if the rate of increase was 1 ft. per hour when the filter was first put into service it might be 3 or 4 ft. per hour when the loss of head reaches 8 ft. If the flocculated matter is not reinforced by microörganisms, or strongly formed gelatinous matter, such as organic and silicious jellies, it is not strong enough to form a mat over the surface that will not break as the loss of head goes up. When the coagulated matter is not reinforced much of it penetrates into the sand bed, the filter runs are longer, and the loss of head increases nearly uniformly throughout the run.

How a Sand Bed Filters.—The sketches in Fig. 1 give the writer's conception of what takes place in a filter bed. They are not to scale and it is evident that the sand grains shown are not as compact as they actually exist in the filter bed. The sketches illustrate what takes place in the top 2 or 3 in. of the sand. The channels are shown larger than actual size, and are also shown in a nearly straight line. It should be evident that they make many turns within the distance of an inch. It would be difficult to show them as they actually exist, but the illustrations serve to show what takes place. It is this channelizing that throws much of the coagulated matter into the sand beds and gives fairly long filter runs. It is our aim in the treatment of water prior to filtration to produce conditions such that this penetration will take place, for no surface filtration will give filter runs within the bounds of what may be considered practical for the efficient operation of rapid sand filtration plants.

When the filter is put into service after washing the water enters the various openings at the top of the sand. The number of openings are perhaps in excess of 100,000 per square foot, and while many of the openings are filled almost immediately after the filter is thrown into service by the heavy coagulated particles not washed away during washing, the openings are still so abundant that the water enters the beds at a fairly slow velocity. Soon the accumulation of coagulated matter, both on the surface and in the bed at the surface, begins to offer resistance to the flow of water. Some of the coagulated matter is forced farther into the bed and that remaining on the surface is forced together more firmly. There is a checking of the flow at points and an increase in the flow at other places. Where there is an increase in the flow the coagulated matter is taken into the bed more rapidly and hastens the stopping up of the pores in that vicinity. The loss of head keeps increasing and the pressure compacts the mat more firmly, making it more resistant to the flow of water and more effective in straining the suspended matter. The mat must eventually break at points, or practically all additional filtration will be by straining at the surface. When the mat forms tough enough not to break it produces the condition shown by the left sketch in Fig. 1. A little of the sand near the surface may have the voids partially filled with coagulated matter, but the amount going beneath the surface is quite small compared to that removed in the mat at the surface. Neither aluminum hydroxide nor ferric hydroxide alone will produce flocculated matter tough enough to produce this condition with sand so coarse as is used in the average rapid sand bed.

Where there is penetration of the coagulated matter into the bed to any material extent the conditions shown in the center and right sketches in Fig. 1 prevail. At first the filtration is like that mentioned in the preceding paragraph, but more of the coagulated matter is taken beneath the surface at the start. When the loss of head builds up a little the mat is not tough enough to prevent breaks. Where breaks occur well defined channels are opened up from the surface down into the sand for a short distance. The channels take a portion of the water with its coagulated matter beneath the surface at very rapid rates. As filtration continues the beds reach a stage in which practically all water enters the sand through open channels. It is evident that the breaks do not all occur at once. It is a break here, there, and yonder, one minute, and elsewhere the next minute. The channels open to a point beneath the clogged sand, then the water begins to branch off in every direction. The water and coagulated matter flows through the channels at such a high velocity little or no coagulated matter is deposited along the sides of the channels in a manner to obstruct the flow. It is only after the velocity has been materially checked by branching that the coagulated matter lodges in the sand voids.

It is not a sudden change from filtration that is largely straining at the surface to filtration from channels beneath the surface, but a gradual transition. Some of the holes may open when the loss of head has increased only a few inches, others may not open until the loss of head has reached its maximum. Where most of the filtration is beneath the surface as is the case in the majority of plants it is likely that most of the holes which open up do so before the loss of head has increased more than about 2 ft. The channels probably

pen before the voids within the sand near the surface are completely filled, and the opening of the channels do not at first stop the flow of water through other portions of the sand, but it lessens the flow. There is still a gradual filling of these voids from the surface, which very likely is aided by some flow from the channels. As this area becomes more thoroughly clogged there is a gradual reduction of the water flowing through the sand in the upper part of the bed except through channels. It should be evident that when the sand voids are nearly filled for an inch or more below the surface it is not likely that additional channels will open through the clogged area from the surface, but the flow will continue through the channels already formed by their being extended deeper into the sand bed as it becomes clogged.

Suspended matter depositing in the sand beyond the ends of the channels gradually clogs the sand and slows up the flow in the channels. Then part of the head which has been taken up by friction loss due to the rapid flow is transferred to a pressure head on the newly clogged area as the flow decreases. The head eventually reaches a point so great that channels are formed through the newly clogged area. The channels probably open in various directions, but the side channels have a limited area of voids to fill before the area is extended to where it comes in contact with other clogged areas. Perhaps it is well to mention that the clogged areas so frequently referred to in this discussion are not the same as the clogged areas frequently mentioned in the literature on filter bed troubles. We are now referring to clogging that is washed away each time the filter is washed.

As soon as the side channels branching from the main channels fill the voids in the area between the main channels, these channels gradually stop up with coagulated matter as is shown for the top side channels in the right sketch of Fig. 1. Many may be of the opinion that the coagulated matter is deposited at the top of the bed and is then gradually forced down through the openings, advancing the material which has previously deposited ahead of the freshly deposited material. If this was the way in which the material was forced farther into the bed there would be a constant disturbing of the coagulated material beneath the surface, which is not the case for most of the material filtered out. It is evident that some of the coagulated matter is occasionally dislodged and forced deeper into the bed, especially when a channel is forced through a clogged area, but this is believed to be a very small per cent of the total coagulated matter. It is the fresh coagulated material going into the bed that keeps extending the clogged area, largely by bypassing the material already deposited. If water having aluminum hydroxide coagulation was filtered through a bed until the pores of the sand were filled from the top down to about 2 in., and then water having ferric hydroxide coagulation was substituted, the ferric hydroxide would go beyond the zone of the aluminum hydroxide to be filtered out and would not advance the aluminum hydroxide ahead of it. There, of course, would be some mixing for filtration in any area is not stopped suddenly.

The number of holes that will open up in a given area of filter surface depends on many conditions. When the coagulated matter contains a certain amount of reinforcing material the holes may not start opening until the loss of head has increased 2 or 3 ft. By the time the main channels have extended 1 to 1.5 in. below the surface the friction head may be so great that the loss of head reaches its maximum. In this case the condition is somewhat like the center illustration in Fig. 1. Such conditions give moderate filter runs, perhaps from 10 to 20 hours when the amount of coagulated matter going on to the filters is not excessive. In this case there will not be the number of channels opening up for a given area as is the case when they start forming at a low loss of head. As previously stated, the coagulated matter will pass through the beds before the loss of head reaches 8 ft. under certain conditions. This is usually accompanied by a large number of channels.

When the coagulated matter extends 12 to 18 in. below the surface of the filter for 8 ft. loss of head, the writer has counted 12 to 15 holes per square inch through the surface of a bed having sand about 0.5 mm. in diameter for the 10 per cent size and 20 to 30 holes in sand about 0.3 mm. in diameter. It is likely that there are about as many channels through the sand as there are holes in the surface. With the large number of holes sometimes found in the surface there must be much mingling of the channels. Two or more channels may unite for a short distance and then branch again. What the water does is to find its easiest path through the filter. Sixteen holes per square inch is an average of one hole for each ¼ in. In this case there could not be much side branching of the channels as is shown by the illustrations. Usually the holes are not so abundant and 2 to 4 per square inch are perhaps about as many as should be expected with moderately long filter runs.

There is another effect that has not been taken into consideration so far in this discussion, and that is the contraction of the coagulated matter as the water is gradually forced out of it by pressure causing it to shrink in volume. We do not think it is possible for the water to be forced out of true jellies with the low pressure that can come into play on the coagulated matter in filter beds, but this coagulated matter is not a true jelly and will contract under pressure. As the compacting takes place it allows a small amount of additional material to be deposited in the clogged areas. It might be well to mention that in referring to the voids being clogged in a given area, they are not completely filled with coagulated matter. Such statements are to imply that the voids are filled to the extent that the flow of water through the area is nearly stopped.

With material so weak in structure as the deposits of flocculated material that is not reinforced in some manner

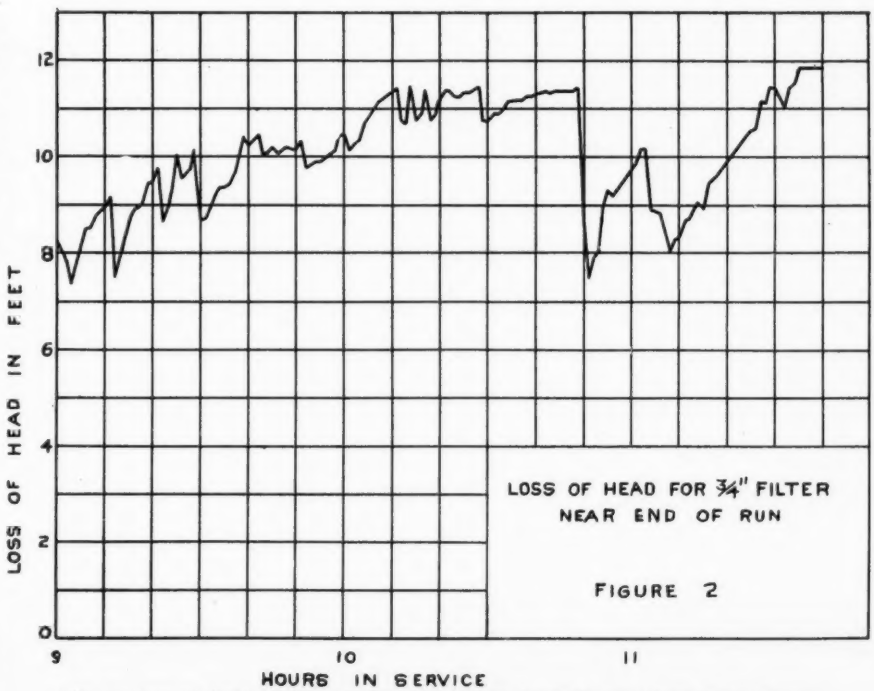


Fig. 2—Loss of Head Readings Taken at 1 Minute Intervals for About Three Hours

it is evident that it does not take much pressure to dislodge quite a great deal of the material and cause some of it to pass through the filter bed, especially if it already has a penetration of 4 to 8 in. Where there is considerable penetration of coagulated matter into filter beds care should be taken to see that the rate of flow through the bed is never increased suddenly. Water containing a great deal of coagulated matter may pass some of it in a very short time. It is more a matter of the volume of coagulated matter that a filter will remove before passing any of the coagulated matter than anything else. If water having a coagulated turbidity of 4 gives filter runs of 80 hours before passing coagulated matter, water with a coagulated turbidity of 400 might pass coagulated matter within an hour. There probably are several factors that will deviate the time from a direct ratio of the coagulated matter, but the volume certainly has the greater influence. With our present knowledge of the influences affecting coagulation it is difficult to predict filter runs or penetration of the material into the beds. No specific rule for filter plant design can be given. The writer favors a treatment prior to filtration that will give a coagulated turbidity of not more than 5. Sometimes this is difficult to attain and it is more economical to handle higher turbidities on the filters, but it is never desirable to purposely throw more coagulated matter on to the beds, as was the belief of many a few years ago. The best procedure is to get the coagulated turbidity as low as is practical with a reasonable expenditure, and then filter out the balance. Perhaps some day the value of the factors influencing toughness of coagulation and filtration can be fixed more definitely.

Observations on Filter Beds.—Some years ago the writer made many observations on what takes place in a filter bed. The work was done largely to determine the cause of cracks and clogged areas in filter beds; however, many observations were made on glass tube filters. Very interesting results were obtained with a glass tube filter approximately ¾ in. inside diameter. This was such a small area that frequently only one hole formed through the surface. It also was small enough so that the effect of the breaks would show on the mercury gauge. Figure 2 shows the loss of head readings taken at one minute intervals for about 3 hours at the latter part of the run. The breaks are defined by the sudden drops in the loss of head. It is believed that most of the sudden drops of about 1 to 2 ft. were caused from side channels opening from the main channel, and that the drop of nearly 4 ft. was caused by the main channel being extended deeper into the sand. This is what is happening over the entire surface of a filter bed, but the breaks do not occur all at once and there is no measureable effect on the loss of head gauge. In fact, filters one and three-fourths inches in diameter do not show much of a jump when a break occurs, for there are usually 6 or more holes in this size filter.

Water Is Variable in Character.—If water was uniform in its characteristics throughout the year its filtering qualities could be determined and the sand used which would be most suitable. Water from a certain supply may vary quite widely throughout the year. In the warmer months it may be difficult to get filter runs long enough for efficient operation, and in the winter months coagulated matter may pass the beds before the loss of head reaches 4 ft. Some waters may go from extreme toughness in coagulation to extreme weakness within a few weeks, indicating the temperature is not the main factor. When the coagulated matter is extremely tough sand 0.5 mm. in diameter for the 10 per cent size and 4 to 5 in. in depth would be sufficient to filter the water clear, but where it is extremely weak sand 0.35 mm. in would require a bed about 4 to 6 ft. in depth to prevent coagulated matter passing the beds if the filters were run to 8 ft. loss of head. Finer sand will have excessive shrinkage and cracks will open, so it is not feasible to solve the trouble by using finer sand. Neither is it feasible to have sand beds 4 to 6 ft. in depth. The most practical thing to do is to wash the filters with a lower loss of head. A bed 24 in. deep will give 40 to 60 hours service before passing coagulated matter under most conditions if there is fairly good settling in the settling basins, and this is long enough for the efficient operation of filters. Any filtration plant having filter runs in excess of 40 hours over any period of the year should be equipped with floc detectors so that the beds may be washed if the coagulated matter starts to go through.

Water in 1877

The Proceedings of the American Society of Civil Engineers has been publishing extracts from a pamphlet written in 1877 by one of its members. Here is what he has to say concerning a water works of that time:

"We visited the water works at Sedalia. They are very extensive. The water is first ground (three-fourths), as I understand it, in order to give the particles held in solution required fineness. It is then allowed to settle, and the surface is drawn off with pipes which lead to the breweries. It looks better as beer; like the eggs the restaurant cook wanted to scramble when a customer ordered them boiled. This was all explained to me in detail by the gentleman who put up the mill for the city, but I can only give an outline of the process here."

Cost of Filter Plant Operation

The water purification plant operated by the Essex Borders Utilities Commission, Windsor, Ontario, has a nominal capacity of 21,000,000 Imperial gallons per day and serves approximately 120,000 people in nine communities. In a paper presented at the 1929 convention of the American Water Works Association, J. Clark Keith, chief engineer of the commission, gave the following cost data on the operation of the plant:

The operating costs for 1928 amounted to $12.58 per 1,000,000 gal. filtered, the percentages of this total being:

	Per cent
Wages	34.1
Power	21.7
Coagulants	16.7
Overhead, taxes, rentals	10.3
Depreciation	5.5
Miscellaneous supplies	3.8
Grounds, and building maintenance	2.8
Heating	2.2
Plant, maintenance	1.6
Laboratory	1.2

The plant is electrically operated with power supplied by the Hydro-Electric Power Commission of Ontario. The rates are $1 per horsepower per month, based on the peak load, 2¼ ct. per kilowatt for the first 50 hours, 1½ ct. for the second 50 hours and 0.33 ct. for all additional power.

The average cost of coagulants per million gallons was $2.09, which incuded the added cost of lime and iron coagulation. During the period when lime and iron coagulation was employed, the average cost per 1,000,000 gal. was $4.09. Alum coagulation during the balance of the year represented an average charge of $.171 per 1,000,000 gal. filtered.

Salaries represented $4.28 of this sum, power $2.74, overhead $2.33, coagulents $2.09 and maintenance $1.24.

The operating staff includes a superintendent, a chief operating engineer, a chief filter operator, three operating engineers, two filter operators and a utility man. The lowest wage paid is 62½ ct. per hour.

The total power consumption for 1928 was $1,455,000 kilowatt-hours, costing an average of 0.82 ct. per kilowatt-hour. The pumping cost for power alone, exclusive of wash water, averages $2.55 per 1,000,000 gal., or 6.7 ct. to raise 1,000,000 gal. 1 ft.

Overhead charges include supervision, rentals paid for use of railway right-of-way, taxes and insurance. A depreciation reserve of $3,000 is set aside annually to replace the heating system, motors and pumps which will need replacement within the 30-year life of the debentures.

Maintenance charges include the general upkeep of machinery, buildings and grounds and the purchase of miscellaneous supplies required in this work. The grounds are attractively maintained as water works plants should be.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor

Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

IN the northern part of the United States the months of January and February find outdoor activities about the average sewage works at a low ebb. It is during this period that the operator finds time to take stock of his plant condition and plan for the spring rush of work which bursts suddenly upon him after the middle of March.

For one thing it is a good time to make leisurely comparisons of analytical data which we have had little more than time to jot down during warm weather. Comparison of data over equivalent periods of time during a number of years is very interesting and instructive.

We may talk of early springs and late springs but it is surprising to note how consistently the white growth (often spoken of as Leptomitus) begin to loosen from the interior of the sewer lines and come into the plant during a certain week of the year; or how closely we may predict the time of the spring unloading of trickling filters.

Trickling filters are particularly sensitive to these seasonal changes. Nitrate oxidation begins to fall off late in the fall reaching a minimum in February. If the connected population is increasing, the rate of fall and the depth of the minimum will increase noticeably from year to year as the plant's capacity is approached. If one is not determining nitrates as a routine matter, a comparison of the results of the methylene blue tests will indicate this increasing winter sag as the capacity becomes taxed nearer to the limit. The magnitude of the variations in oxidation during weekly cycles is also indicative of the approach to bed capacity. That is to say, a plant with abundant capacity will hardly show the weekly cycle, but a trickling filter approaching capacity will show a decided increase in oxidation after the Sunday recuperation due to weak sewage on that day. The decrease in oxidation during the balance of the week will indicate to the experienced operator the margin of reserve powers.

Time Records

In January also the operator is planning the year's budget, is probably making an effort to secure special appropriations for improvements the need of which has been brought home to him by comparison of laboratory operating data. All too often he will have to secure these appropriations from new councilmen or new committeemen who are taking charge of the plant at the beginning of the year and are entirely unfamiliar with the work.

A good time record will be found very valuable in presenting the needs to the committee in charge; not that the time record should be handed over to the committee as such. Human nature is a funny thing; a nice neat tabulation of this kind presented to a newly made, ambitious councilman who is, perhaps, overfeeling the importance of his new station, might produce a number of unlooked for reactions. For instance, it might send him off on a wild economizing spree with very unfortunate results.

The thought which we wish to express is, that the operator should have a personal record of the time spent on various parts of the plant so that when he sees the need for a particular improvement he may be able to state with confidence the exact effect on the economical management of the works. Below is a typical week's record of a plant consisting of fine screen, Imhoff tanks, sprinkling filters and resettling tank, where the sludge is moved by a team.

There are, of course, many little items which we cover under Odd Jobs. We do not burden ourselves with splitting time beyond the nearest half-hour because our object is to produce a bold picture showing in relief the main time absorbing items.

The below sample record would assist in answering the following questions: Would a tractor be more economical than a team for hauling sludge? (Note the fixed loss daily in caring for barn and team.) Would it pay to install separate settling tanks with mechanical sludge removal? (Note time spent on various parts of Imhoff tanks.) Would it pay to install a sand trap? (The week chosen is one of perhaps five during the year in which a settling tank has been shut down for removal of sand.)

At one plant such a record was summarized as follows:

Night watchman	$ 4.50
Care of tanks	13.50
Balance of plant	6.50
Total daily cost of operation	$24.50

The care of tanks runs into the sizable item of $4,000 for 300 working days, or almost exactly 50 per cent of the annual labor charge. This $4,000 also equals 6 per cent interest on $65,000 and calls for careful consideration of the possibility of reducing costs by installing separate settling tanks and mechanical sludge removers.

Data on Sewage Solids

A record of suspended solids in settling tank influent and effluent is very instructive and is essential to intelligent operation. On page 12 is a typical 10-year record covering suspended solids in tank influent and effluent expressed as parts per million, and solids retained, expressed as parts per million as well as in pounds of solids retained and as cubic feet of resultant sludge. Together with the solids record are given the rainfall, sewage flow, and estimated contributing population.

This table helps to explain many things. The fact that the flow of sewage in M.G.D. remains fixed while the population has steadily grown is due to the fact that metering of the water services in the tributary territory has been progressive over the period and

Labor Distribution at a Disposal Plant

Item	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Barn	2:00	2:00	2:00	2:00	2:00	2:00	2:00
Screenings	.....	1:00	1:00	1:00	1:00	1:00	1:00
Watchman	22:00	14:00	14:00	14:00	14:00	14:00	14:00
Sludge pump	.....	.....	.....	.....	4:00	.....	.....
Imhoff tanks							
Set. compartments	.....	8:00	8:00	:30	1:00	2:00	1:00
Vents	.....	5:00	14:00	8:00	.....	4:00	5:00
Slots	.....	5:00	2:00	2:00	10:00	3:00	5:00
Final tank	.....	.....	.....	.....	.....	16:00	16:00
Cart sludge	.....	7:00	7:00	7:00	6:00	.....	.....
Spray flies	.....	1:00	1:00	1:00	1:00	1:00	1:00
Care grounds	.....	.....	.....	.....	.....	10:00	.....
Sand from tanks	.....	8:00	16:00	16:00	18:00	12:00	12:00
Clean nozzles	.....	.....	.....	.....	.....	.....	.....

Data on Sewage Solids

Year	Rain Inches	Parts per Million Screened	Settled	S. Solids Retained	Flow MGD	DAILY Pounds Retained	Cu. Ft. 95-5%	Population Mid-Year	Per Cent Solid Retained
1920	41	161	66	95	3.7	2,945	942	34,500	59
1921	38	150	59	91	3 2	2,411	777	35,700	60
1922	40	147	77	70	3.3	1,925	616	36,800	48
1923	36	188	89	99	3.3	2,722	671	38,500	52
1924	46	212	120	92	3.3	2,530	809	40,500	43
1925	39	216	96	120	3.2	3,202	1,024	42,300	55
1926	44	218	92	126	3.3	3,357	1,074	45,550	58
1927	46	230	104	126	3.3	3,465	1,107	48,000	55
1928	46	223	100	123	3.5	3,567	1,139	53,500	55
1929	41	234	111	123	3.5	3,567	1,139	53,795	53

has recently reached nearly 100 per cent, reducing per capita consumption from 100 gal. to little over 60 gal. The increase in suspended solids in the screened sewage checks this statement.

The increase in suspended solids retained subsequent to 1924 is due to changing from Imhoff tanks to separate settling tanks.

The apparent reduction in suspended solids retained in 1929 from 55 per cent to 53 per cent is probably due to the fact that during this year a sand trap was in operation and removed a weight of quickly falling solids equal to nearly 6 per cent of the suspended solids in the screened sewage. Not all of this would have reached the screen effluent had the sand trap not been in operation, but certainly a portion of it would have done so.

A very complete record of house connections has always been kept in connection with this plant and is a record which is recommended in every case. The population is estimated by multiplying the number of individual house connections by 5.

As previously indicated the purpose of these notes is to interest the operator in keeping records and to interest his superior in supplying him with the equipment for securing proper records, and to interest city officials in general in the value of employing operators who are capable of making chemical determinations and keeping proper records.

Dosing Siphons

Except that they gradually become somewhat sluggish in action, over a period of years, dosing siphons of the air lock type, with no moving parts, give so little trouble that one is more or less at a loss when they do fail to work properly.

Recently one of these siphons under the writer's supervision became so sluggish that an inordinate proportion of the flow was diverted to another section of the sprinkling filters with a consequent drop in the quality of the effluent. A description of the method of handling the situation may be helpful to operators of other plants.

The plant has two independent siphons, each supplying one-half the filter bed area from a common source. Hence any slowing up of one siphon would result in under-dosing one-half the bed and over-dosing the other half. The flow is so great that one siphon alone will take the entire flow only in the early morning hours. The time available for discovering and correcting the difficulty is, therefore, very much limited.

When the flow of sewage to the plant was very low the supply to the faulty siphon was cut off by means of stop planks just after this siphon had started to operate. When the discharge was complete hasty examinations were made and such obvious possible difficulties as sticks or grease balls in the elbows of the trap piping were eliminated.

Finally, realizing that time for a more than casual inspection was imperative, we set a 3 in. diaphragm pump of the ball valve type in such a position that it would take care of any seepage through the stop planks and set to work very early in the morning. All the trap piping was taken down and all pipe and elbows found to be clear. But it was found that the entire inside of the siphon bell was coated to a depth of an inch or more with grease and that this grease had "grown" entirely across the 1¼ in. orifice leading to the trap. The surprising thing about it was that the siphon worked at all under these conditions.

When the grease was cleared out of the orifice this siphon was found to make 193 shots per day as compared with 115 for a comparable flow before cleaning. The difference is made up of the few seconds per shot necessary to force the air out of the plugged hole and the quantity of sewage previously diverted to the other siphon.

With the balance between the two sides of the filter, and the balance between the discharge and resting periods restored, the quality of the filter effluent began to improve immediately.

Reverting again to the matter of records; it was only because of the fact that records of the number of siphon doses were available that we were able to explain the slump in effluent quality and to correct the trouble before it became even more serious.

In connection with our remarks in the December, 1929, article on Developments in the Art of Sewage Disposal, Chas. C. Hommon, Superintendent of Sewage Disposal for the City of Canton, O., has kindly prepared the following notes on controlling growths and deposits in sewage trickling filters:

Controlling Growths and Deposits in Sewage Trickling Filters

By CHAS. C. HOMMON

During the past two years the writer has had opportunity of visiting some seventy-five sewage treatment plants, employing trickling filters, to determine among other things the cleanliness of the aggregate. The many observations enabled one to draw the conclusion that many of the filters were retaining excessive amounts of organic deposits, regardless of the type of filtering material employed. Many of the beds were excessively dirty and others were clogged to the extent of surface pooling, some of them resembling miniature lakes. Laboratory data to show the efficiency of the more seriously clogged beds were not available, but it is assumed that but little nitrification is possible under such conditions. Inquiry from the plant superintendent as to what was being done to relieve the stoppage usually brought forth the statement that sooner or later the bed would automatically unload and that eventually all would be well. The writer has experienced many uncomfortable intervals waiting for nature to take its course in such matters. In most instances nature has been quite successful in maintaining the filters in such condition as to permit reasonable use of the filters but has often failed in completely renovating the aggregate.

To determine the feasibility of controlling the surface algae growths and organic accumulations that are normally deposited in sewage filters considerable care has been given to the operation of the filters at the Canton, Ohio, plant.

The Canton sewage works were placed in service during the spring of 1927. The filter area consists of 6.75 acres, divided into four units, each unit being provided with a suitable sluice gate for flooding the filtering material. The filters have a nominal depth of 7 ft. and are filled with crushed blast furnace slag ranging in size from 1½ in. to 2¾ in. in diameter. The filters were designed for a population load of 8,855 per acre foot and the estimated present load is 2,330 persons.

During the first year of operation the total filtering area was maintained in continuous service after which time the aggregate was what may be called normally dirty; in some areas the voids were practically filled with black deposits and some slight evidence of surface ponding was noticeable. On one occasion prior to 1928 a slight unloading occurred but not sufficiently complete to say that the filters were clean. Beginning in late Spring of 1928 a systematic resting and flooding schedule was established and followed until the present time with the exception that during the colder months of the year flooding is omitted. Numerous inspec-

tions of the surface of the beds, together with a number of test pits dug to varying depths at different points in the filters, indicate that the aggregate is practically as free from organic deposits as when it was placed at the time of construction. A recent failure of a part of the concrete collecting gallery served to show very clearly the cleanliness of the aggregate. At the time of failure of the concrete wall a considerable quantity of the slag was washed out of the filter into the effluent channel, exposing the slag within the bed from the top to the underdrains. With the exception of a few small areas, where some fine aggregate existed, there were practically no organic deposits noted, and the underdrains were likewise quite free from foreign deposits. Comparing the condition of the filtering material after approximately one year's service under what may be called normal operating conditions with that of two years' service during which time periodical drying and flooding was practiced, it appears that one is justified in believing that it is possible to control the cleanliness of the filtering aggregate within rather close limits.

The cutting out of service of any one of the filter units during the drying period necessarily increased the load on the remaining active units but this increase has not materially affected the efficiency as nearly as can be determined by the usual laboratory analysis of the effluent. As previously noted the present estimated filter load is 2,330 persons per acre foot which is increased to approximately 3,100 persons per acre foot during the time of resting one of the units. In practice it means that the filters have been operated for the past two years at the higher rate for the reason that at all times at least one bed has been out of service. For experimental purposes the rate has been increased to 4,660 persons per acre foot for periods up to three weeks. During these high rates of application the nitrification was reduced somewhat but not to the point of materially affecting the general character of the filter effluent.

If the experience at Canton may be taken as a criterion there appears to be no doubt that it is feasible and desirable to control the deposits that normally collect in sewage trickling filters. Cleanliness not only promotes more satisfactory operation of sewage sprinkling filters but perhaps will permit of higher rates of application of sewage and greater length of service.

Sewage Treatment at Philadelphia

The following is a statement by Mr. John E. Allen, Principal Assistant Engineer, Bureau of Surveys of the City of Philadelphia, with regard to the matter of future treatment of sewage in that city as referred to in our December article:

"The City of Philadelphia is faced with the condition at the Northeast Works of insufficient diluting water to receive the discharge from the Northeast Works without additional refinements to the present Imhoff tank process. Research work, which has been carried on for several years, indicates that the Imhoff treatment will be superseded by aeration of sewage, sedimentation, a continuous removal of deposited solids, and the incineration of these solids. The results of this research work indicate the almost complete removal of settleable and suspended solids and over a 90 per cent removal of bacteria. This will, of course, increase the amount of sludge to an extent that makes desirable some method of reducing the bulk and facilitating the final disposal. It is hoped to obtain this by incineration and experimental work has shown a destruction of organic matter and a reduction in bulk to about 15 per cent of ash by burning. The design of incinerator under study is intended to receive the sludge as it is delivered from the sedimentation stage and without intermediate de-watering machinery.

The entire sewage treatment program of the City of Philadelphia anticipates the handling of 1,100,000,000 gal. daily and the resulting sludge volume under this process is estimated at 5,000 cu. yd. daily of wet sludge. This result desired has not yet been attained in the incinerator designed but experimental work gives promise to success."

Cleaning Submerged Outfall Sewer

The cleaning of the under-sea section of the outfall sewer of the city of Santa Barbara, Calif., involved some interesting methods which are described in a recent issue of the California Constructor.

The 42 in. line extends 3,400 ft. into the ocean and at its outer end is 50 ft. below the surface. The earthquake of 1925 caused movement that separated some of the joints so that sand has been filtering into the pipe through crevasses at the joints, clogging the interior to such an extent that sewage, which is forced down the pipe by pump, cannot reach the lower end of the line. During the past summer the sewage has been discharging through a manhole in the line 300 ft. from the beach.

The contract let to Charles H. Johnston, Los Angeles, Calif., at $40,000, called for the cleaning of the sand from the line, and for the re-caulking of the joints. The cleaning work was accomplished by two divers who worked inside of the line, and who were tended from a barge above them that also carried sand pumps. The two men also re-caulked the joints, using air hammers for this work.

The methods employed were similar to sand moving work on shore, adapted to the conditions of the job. One of the features of the work was the employment of the two divers, who spent seven hours per day under water for a four month period. The maximum depth of 50 ft. at which they worked was not excessive, but there have been very few single jobs in the past in which divers have been called upon to spend so large amount of time beneath the surface.

The divers were fitted out in regulation Navy diving gear and carrying telephone sets. Each was assisted by a tender on the barge. The barge had a crew of one engineer and two seamen, who operated the sand pump, the telephones, and the air compressor. The air compressor discharged into a reservoir that contained a maximum of a half hour supply of air. An auxiliary hand air pump was connected into the air lines, so that in case of failure of the air compressor, the divers could be fed from the hand pump and from the reservoir.

Operations began from the beach end of the sewer line. Manholes are 250 ft. between centers on the pipe. After the barge was spotted above the first manhole, the divers descended and pulled off the manhole cover. An 8-in. suction line was dropped from the barge to the divers, who pulled it into the sewer line. The line was found to be nearly full of sand, except for a space of from 6 in. to 1 ft. along the top. The end of the suction line was forced into the sand, which was carried through the pump on the barge and discharged over the side.

The divers worked in absolute darkness inside of the sewer line and had a great deal of difficulty in handling the heavy suction line. By squirming along the top of the sand, the divers were able to insert a trench jack across the sewer line some distance ahead of their work. A steel cable from a winch on the barge was passed through a block attached to the jack and was tied on to the end of the suction line. By speaking through their telephone sets, the divers were able to direct the barge attendants to operate the winch, dragging the suction line further into the sewer as the work progressed. A steel cable was lashed to the suction line and took the pull of the winch.

Cleaning was done from manhole to manhole, after which the section was walled up to prevent the sewage from following the work of the divers, it meanwhile discharging through the manholes, which were left open. The sewer line was "swept out" after most of the sand had been pumped away, with a 2-in. jet of water under 100 lb. pressure.

C. D. Curry was superintendent for the contractor.

Alternate Wet and Dry Periods of 11.2 Years Shown by California Sequoias for 3125 Years

By HALBERT P. GILLETTE

IN *Water Works and Sewerage*, November, 1929, it was shown that the rainfall records of central and southern California disclose an alternation of wet and dry periods of 11.2 years, and that this same periodic alternation can be traced back for 500 years in the radial growth of Arizona pines. In the present article an account will be given of a similar alternation disclosed by study of the annual ring thicknesses of the California giant redwoods or sequoias.

The measurements of sequoia annual growth are those made by Prof. A. E. Douglass of the University of Arizona ("Climatic Cycles and Tree Growth," pub. by Carnegie Institution). From study of his measurements of tree rings Prof. Douglas inferred that about every 11.4 years there occurs a growth greater than normal, lasting a year or so, also that about midway between these years of "peak" growth there is frequently another year or two of "peak" growth. I do not intend discussing this phenomenon now, further than to say that he erred somewhat as to the 11.4-year interval between "peaks." To be exact it averages 11.21 years, corresponding with the sunspot peak caused by the effect of Jupiter's magnetic field, which attains its maximum when Jupiter's north magnetic pole points most nearly sunward.

Both Huntington and Ricard have shown that sunspots produce barometric changes, and it is inferable that the polarity of the spots determines the nature of these changes. Hale has shown that about midway between the so-called 11-year sunspot "peaks," the new series of sunspots (starting in high latitudes) has a polarity that is the reverse of that of the old series in each hemisphere. By combining these facts I inferred that there should be an alternate 11.2-year weather cycle at least in some parts of the earth, and it should show great persistency. This inference was abundantly confirmed by the data relating to the growth of Arizona pines (as shown in my article above mentioned), and it is amazingly confirmed by the sequoia tree growth records, which run back six times as far as those of the Arizona pines.

In checking my investigation, let the reader start with the Jupiter sunspot peak of July, 1917 (or 1917.6) and calculate the dates of preceding Jupiter maxima by assuming a regular cycle of 11.21 yrs. This will bring a Jupiter peak in August of the first year of the Christian era (0.7 A. D.), and another in Feb. 1221 B. C. (1221.2 B. C.). Since tree rings show only annual growth, and since hair splitting is not called for, take the nearest year preceding a Jupiter peak date, and regard it as the first year of an 11-year period. It will be necessary either to have a 12-year period every 55 years, or to skip a year; and since it is immaterial which is done, I have skipped a year at intervals, as indicated in Table I.

In considering whether an 11-year period is wet or dry, find the mean of the tree growth for the two 11-year periods on each side of the 11-year period under consideration. If that mean of the two periods exceeds the growth during the period under consideration, then the period under consideration is relatively dry; and if conversely, it is wet.

Between 1221 B. C. and 1906 A. D. there are 279 periods of 11.21 years. Of these periods only 52 depart from a regular alternation of wet and dry periods; and 10 of the 52 are turning points where reversals occur in the alternating series. (See Table I.) By this I mean that either two wet or two dry periods occur in sequence, followed by a renewal of the alternate wet and dry periods. The following are the initial years of each of these 10 reversal or turning points in sequoia tree growth.

The second column of Table II shows the years between successive reversals of the 11.2-year cycles. It is noteworthy that there was one span of 953 years in which alternate wet and dry periods (11.21 yr.) occurred with only an occasional interruption, or failure to agree with the alternating wet and dry sequence. Such interruptions were probably caused by an unusually strong magnetic effect due to some planet. In fact, during this span of 953 years there were 85 periods of 11 years, and of these only 13 departed from the alternate wet and dry sequence. In every one of these 13 instances the departure was toward increased rainfall, thus producing three successive wet periods.

Of the 42 breaks of this sort during the 279 periods of 11 years, 34 were such as to cause three wet periods to occur in sequence.

I believe that the 10 reversal points in Table II were due to 10 changes in the preponderance of sunspots in the northern over those in the southern hemisphere; and that these changes depend upon the positions of certain planets relative to the plane of the sun's equator.

It is noteworthy that the lengths of two of these spans are almost 280 years. This may indicate the effect of a planet whose orbital period is about 560 years.

Unless the mathematical laws of probabilities are invoked, the full significance of an accord between theory and fact is rarely appreciated. In this case the result of a probability calculation is quite amazing. Thus, what is the probability that in 237 out of 279 periods an alternate wet and dry sequence would occur by accident?

Applying the "binomial formula"

Table I—Alternate Wet and Dry Periods (11.2 Years) in California as Shown by Sequoia Rings, Back to 1220 B. C. (See Foot Note)

11-Yr. Period A. D.	Average Annual Thickness of Rings in Millimeters	Relative Wetness	
1895-05	0.96	Dry	
1884-94	1.11	Wet	
1873-83	.99	Wet	(Failure to agree)
1862-72	.81	Wet	(Reversal of cycle)
1851-61	.85	Wet	
1839-49	.82	Dry	
1828-38	.82	Wet	
1817-27	.85	Dry	
1806-16	.90	Wet	
1794-04	.98	Wet	(Failure to agree)
1783-93	.95	Wet	
1772-82	.89	Dry	
1761-71	1.09	Wet	
1749-59	.91	Dry	
1738-48	.94	Wet	
1727-37	.87	Dry	
1716-26	.81	Wet	
1704-14	.75	Dry	
1693-03	.73	Dry	(Failure to agree)
1682-92	.75	Dry	
1671-81	.86	Wet	
1660-70	.80	Dry	(Reversal of cycle)
1649-59	.76	Dry	
1638-48	1.01	Wet	
1627-37	.82	Dry	
1616-26	.90	Wet	
1604-14	.88	Dry	
1593-03	.80	Dry	(Failure to agree)
1582-92	.74	Dry	
1571-81	.59	Dry	(Failure to agree)
1560-70	.83	Dry	
1548-58	.87	Wet	
1537-47	.93	Wet	(Failure to agree)
1526-36	.90	Wet	
1515-25	.93	Dry	
1504-14	.98	Wet	
1492-02	.86	Dry	
1481-91	.89	Wet	
1470-80	.74	Dry	
1459-69	.76	Wet	
1447-57	.73	Dry	
1436-46	.79	Wet	
1425-35	.84	Dry	
1414-24	1.12	Wet	
1403-13	.84	Dry	
1391-01	.93	Wet	(Reversal of cycle)
1379-89	1.08	Wet	
1368-78	1.05	Dry	
1357-67	1.07	Wet	
1346-56	.90	Dry	
1335-45	1.15	Wet	
1323-33	1.16	Wet	(Failure to agree)
1312-22	1.13	Wet	
1301-11	.85	Dry	
1290-00	.87	Wet	
1278-88	.86	Dry	
1267-77	.91	Wet	
1256-66	.85	Dry	
1245-55	.77	Dry	(Failure to agree)
1234-44	.76	Dry	
1222-32	.86	Wet	
1211-21	.90	Dry	
1200-10	.96	Wet	
1189-99	1.00	Wet	(Failure to agree)
1178-88	.93	Wet	
1166-76	.88	Dry	
1155-65	.86	Wet	
1144-55	.83	Dry	
1133-43	.97	Wet	
1121-31	.89	Dry	
1110-20	1.08	Wet	(Reversal of cycle)
1099-09	.95	Wet	
1088-98	.91	Dry	
1076-86	1.08	Wet	

11-Yr. Period A. D.	Average Annual Thickness of Rings in Millimeters	Relative Wetness	
965-75	1.16	Wet	(Failure to agree)
954-64	.84	Wet	
943-53	.95	Dry	
932-42	1.13	Wet	
920-30	1.34	Wet	(Failure to agree)
909-19	1.35	Wet	
898-08	1.37	Wet	(Failure to agree)
887-97	1.26	Wet	
875-85	.99	Dry	
864-74	1.16	Wet	
853-63	.93	Dry	
842-52	1.08	Wet	(Reversal of cycle)
831-41	1.07	Wet	
819-29	1.06	Dry	
808-18	1.08	Wet	
797-07	1.12	Dry	
786-96	1.19	Wet	
775-85	1.18	Wet	(Failure to agree)
763-73	1.04	Wet	
752-62	1.09	Dry	
741-51	1.15	Wet	
730-40	1.20	Wet	(Failure to agree)
719-29	1.12	Wet	
708-18	1.05	Dry	
697-07	1.14	Wet	
686-96	1.11	Dry	
675-85	1.37	Wet	
663-73	1.07	Dry	
651-61	.99	Dry	(Failure to agree)
640-50	1.22	Dry	(Failure to agree)
629-39	1.31	Wet	
618-28	1.04	Dry	
607-17	1.18	Wet	
595-05	1.29	Wet	(Failure to agree)
584-94	1.33	Wet	
573-83	1.36	Dry	
562-72	1.50	Wet	
551-61	1.32	Dry	
539-49	1.32	Wet	
528-38	1.32	Dry	
517-27	1.51	Wet	(Reversal of cycle)
506-16	1.33	Wet	
494-04	1.11	Dry	
483-93	1.06	Wet	
472-82	1.00	Dry	
461-71	1.15	Wet	
450-60	.94	Dry	
438-48	1.02	Wet	
427-37	1.24	Wet	(Failure to agree)
416-26	1.21	Wet	
405-15	1.57	Wet	(Failure to agree)
394-04	1.70	Wet	
382-92	1.64	Dry	
371-81	1.48	Wet	
360-70	1.33	Dry	
349-59	1.45	Wet	
337-47	1.76	Wet	(Failure to agree)
326-36	1.96	Wet	
315-25	1.91	Wet	(Failure to agree)
304-14	1.66	Wet	
293-03	1.36	Dry	
281-91	1.64	Wet	
270-80	1.42	Wet	(Failure to agree)
259-69	1.04	Wet	
248-58	.87	Dry	
237-47	.75	Dry	(Failure to agree)
225-35	.81	Dry	
214-24	.91	Wet	
203-13	.86	Dry	
192-02	1.04	Wet	(Reversal of cycle)
180-90	.96	Wet	
169-79	.85	Dry	
158-68	.96	Wet	
147-57	.91	Dry	
136-46	.93	Wet	
124-34	.99	Dry	
113-23	1.14	Wet	
102-12	1.42	Wet	(Failure to agree)
091-01	1.40	Wet	
080-90	.98	Dry	(Reversal of cycle)
068-78	.86	Dry	
057-67	1.02	Wet	
046-56	1.04	Dry	
035-45	1.06	Wet	
024-34	.99	Dry	
012-22	1.35	Wet	
001-11	1.06	Dry	
90-00	1.25	Wet	
79-89	1.48	Wet	(Failure to agree)
68-78	1.30	Wet	
56-66	1.21	Dry	
45-55	1.56	Wet	
34-44	1.90	Wet	(Failure to agree)
23-33	1.91	Wet	
12-22	1.47	Dry	
0-10	1.65	Wet	
B. C.			
1-11	1.39	Dry	
12-22	1.47	Wet	
23-33	1.61	Wet	(Failure to agree)
35-45	1.63	Wet	
46-56	1.64	Dry	
57-67	2.16	Wet	(Reversal of cycle)
68-78	2.18	Wet	
79-89	1.86	Dry	
90-00	1.84	Wet	
102-12	2.41	Wet	(Failure to agree)
113-23	2.31	Wet	
124-34	2.20	Dry	
135-45	2.31	Wet	
147-57	2.25	Wet	(Failure to agree)
158-68	1.97	Wet	
169-79	2.28	Dry	
180-90	2.60	Wet	
191-01	2.36	Dry	
203-13	2.25	Wet	
214-24	1.41	Dry	
225-35	1.20	Wet	
236-46	1.43	Dry	
247-57	2.45	Wet	
259-69	2.64	Dry	(From 270 to 274 the average yearly growth was 3.56)
270-80	.73	Wet	(A different group of trees starts here)
281-91	.76	Dry	
292-02	.84	Wet	
304-14	.86	Wet	(Failure to agree)
315-25	.77	Wet	
326-36	.69	Dry	
337-47	.72	Wet	
349-59	.78	Dry	
360-70	.90	Wet	
371-81	.94	Wet	(Failure to agree)
382-92	.77	Wet	
393-03	.75	Dry	
405-15	.84	Wet	
416-26	.73	Dry	
427-37	.93	Wet	
438-48	.85	Wet	(Failure to agree)
449-59	.75	Wet	
461-71	.93	Wet	(Failure to agree)
472-82	1.06	Wet	
483-93	1.01	Dry	
494-04	1.04	Wet	
505-15	.93	Dry	
517-27	.86	Wet	
528-38	.89	Dry	
539-49	1.23	Wet	
550-60	.95	Dry	
561-71	.86	Wet	
573-83	.77	Dry	
584-94	.92	Wet	
595-05	1.01	Dry	
606-16	1.09	Wet	
617-27	1.18	Wet	(Failure to agree)
629-39	1.12	Wet	
640-50	1.08	Dry	
651-61	1.21	Wet	
662-72	1.34	Wet	(Failure to agree)
674-84	1.34	Wet	
685-95	1.64	Wet	(Failure to agree)
696-06	1.48	Wet	
707-17	1.34	Dry	
718-28	1.35	Wet	
730-40	1.34	Wet	(Failure to agree)
741-51	1.32	Wet	
752-62	1.21	Wet	(Failure to agree)
763-73	1.09	Wet	
774-84	1.08	Dry	
786-96	1.16	Wet	
797-07	1.12	Dry	
808-18	1.08	Wet	
819-29	1.34	Dry	
830-40	1.51	Wet	
842-52	1.17	Dry	
853-63	1.26	Wet	
864-74	1.66	Dry	
875-85	2.21	Wet	
886-96	2.14	Wet	(Failure to agree)
898-08	1.95	Wet	
909-19	1.68	Dry	
920-30	2.21	Wet	
931-41	1.71	Dry	
943-53	1.37	Dry	(Failure to agree)
954-64	1.17	Dry	
965-75	1.24	Wet	
976-86	1.20	Dry	
987-97	1.30	Wet	
999-09	1.30	Dry	
1010-20	1.40	Wet	(Reversal of cycle)
1021-31	1.60	Wet	
1032-42	1.39	Dry	
1043-53	1.44	Wet	
1055-65	1.35	Dry	
1066-76	1.95	Wet	
1077-87	1.75	Dry	
1088-98	2.07	Wet	
1099-09	2.07	Dry	
1111-21	2.19	Wet	
1122-32	2.69	Wet	(Failure to agree)
1133-43	2.90	Wet	
1144-54	2.78	Dry	
1156-66	3.00	Wet	
1167-77	3.59	Wet	(Failure to agree)
1178-88	3.67	Wet	
1189-99	3.31	Dry	
1200-10	3.28	Wet	
1211-20	3.17	Dry	

Note: An 11-year period is "wet" if its average annual ring thickness is greater than the mean ring thickness of the preceding and following 11-year periods; and conversely as to "dryness."

Table II—Dates of Reversal of the 11.2-Year Cycles

Date of Reversal	Years Between Reversals
1862 A. D.	202
1660 A. D.	279
1391 A. D.	281
1110 A. D.	168
942 A. D.	325
617 A. D.	325
292 A. D.	112
180 A. D.	237
57 B. C.	953
1010 B. C.	

Note: From 1010 B. C. to 57 B. C. there were 85 periods of 11.2 years in which there was an alternation of wet and dry periods in every instance except 13, and those 13 periods were wet whereas they would have been dry had the alternating sequence been unbroken. Then the 11-year period beginning 57 B. C. introduced a reversal of alternation of wet and dry periods, as shown in Table I.

(Fry's "Probability and Its Engineering Uses," p. 63) we find that there is only one chance in 6.8×10^{33} that it is accidental. Since it is more impressive to express this ratio without the use of exponents, let us do so; it is one in 6,800,000,000,000,000,000,000,000,000,000,000, or nearly seven trillion quadrillion. Even if we consider only the series of 11-year periods from 1010 B. C. to 57 B. C. we have 85 periods in which only 13 breaks in the sequence occur. This gives for the "binomial formula" m=84 and n=13, from which we deduce that this could have occurred accidentally only 1 time in 17 billion.

No relationship between sunspots and weather has hitherto been so conclusively established by an appeal to the laws of probabilities.

Incidentally two important facts are also established: First, that the so-called 11-year sunspot cycle can not differ much from 11.21 years, for if it did, the alternation of wet and dry periods of the assumed 11.21 years would have ceased long before 1220 B. C. had been reached. Second, it becomes evident that Hale's periodic change in the polarity of sunspots is not an ephemeral affair, but has existed for at least 3,100 years.

In a later article I will show that the frequent alternation of wet and dry years is due to the existence on Jupiter of 12 permanent magnetic whirls, similar to the 12 molten whirls which, by the air of topography I have located in the earth. The centers of those molten whirls were given in an article in "Engineering and Contracting," October, 1929, p. 425. The location of the center of whirl C was incorrectly given there; it is 40° N., 132.5° E., being almost in the center of the Sea of Japan. This particular molten whirl explains not only the circular form of that sea, but the persisting volcanic activity of that region.

Corresponding to these 12 molten whirl centers, and not far from them, are the centers of 12 permanent anticyclones, thus showing that both the molten interior of the earth and the air above the earth are similarly energized.

A discussion of the 12 molten whirls will appear in "Engineering and Contracting," together with data that prove

the existence of each of them. The laws of probability will be used to show that the existence of arc-shaped mountain ranges, arc-shaped chains of islands, etc., around these 12 centers is highly improbable unless permanent whirls have existed ab initio in the earth's molten interior. Since free electrons under the influence of magnetic fields acquire rotary motion about lines of magnetic force, it is clear that the molten whirls in the earth are electromagnetic phenomena. The same is true of air whirls, from the smallest to the largest, from the most enduring to the most ephemeral.

Aerial Surveys for Reservoir Project

How They Were Used to Aid Ground Surveys for Swift Power Reservoir in Massachusetts

THE Metropolitan District Water Supply Commission of Boston, Mass., has had considerable experience with aerial photography in connection with a projected new water supply development. In a recent discussion before the Boston Society of Civil Engineers, N. LeRoy Hammond, Division Engineer of the Commission, described how the aerial surveys were used for the proposed Swift River Reservoir. The notes following are taken from his discussion.

The contract with Fairchild Aerial Surveys, Inc., was for the aerial survey of the area to be affected by the proposed Swift River Reservoir, and was in preparation of extensive ground surveys of that area.

The science of aerial photography is relatively new, and while many engineers have been interested casually and are always anxious to view the aerial photographs, yet they are inclined to be somewhat skeptical as to their practical value, particularly where one user will dwell on the accuracy of results, while another will claim that but little accuracy can be obtained. From the experience in the Swift River Valley the aerial survey is a valuable asset to the work of the field engineer.

What the Contract Covered.—The contract called for the photographing of some 100 square miles of area. The Swift River Valley is characterized by a series of high ridges from three to four miles apart, running generally in a northerly and southerly direction. Scattered through the floor of the valley are also numerous hills rising sharply 500 to 700 ft. above the river level. For the purpose of photography, the natural course for the flight of aircraft was in a northerly and southerly direction along the axes of the various valleys. With the contract calling for an overlap of 50 per cent there resulted a large number of contact prints of the entire area. The photographs were taken at a flight elevation of between 10,000 and 12,000 ft. above sea level, which resulted in contact prints 7 by 9 in., with a scale of approximately 1,100 ft. to the inch. The contract also provided for enlargements to a scale of 1 in. equals 400 ft., with control data for such enlargement to be supplied by the engineers of the commission. Aside from the Massachusetts topographic maps, there was little data available for proper control because actual ground surveys had advanced but slightly when the aerial photographs were taken. Furthermore, as the object of aerial photography was to aid the ground survey, it became necessary to secure control data within the shortest possible time.

Determining Enlargement Ratios.—An attempt was made to scale from the United States topographic maps the distances between intersections of highways to compare with the photograph of the same highways shown on the contact prints, but as many prints showed but small stretches of such highways this method was found to be impracticable. Finally, distances from definite points on each contact print, such as known houses or other outstanding features, were actually measured by roughly dragging a long chain between these points, generally along the highways. The scale of various sections of each contact print was then approximately determined and a ratio for enlargement evolved. Considerable variation of scale of different portions of each contact print were found, due largely to differences of from 500 to 600 ft. in ground elevation with resultant camera distortion. The contact prints were particularly clear, and it was decided that in general little would be gained by having enlargements, and consequently only a few of the contact prints were enlarged by the photographic process. Had the area been more uniformly of the same elevation, it is probably that enlargement ratios would have been more easily determined and an actual aid would have resulted in having all photographs to the same scale.

Many Uses of Contact Prints.—The uses of the contact prints have been many. The area which was photographed will ultimately be acquired by purchase or otherwise, and involves a considerable task in the examination of title of real estate holdings. In the case of three of the towns in the valley approximate real estate maps were made by the use of the contact prints. Each print was carefully studied and every indication of a property line was pantographed to a skeleton map of the town. The resultant plot was then taken into the field in company with an assessor of the town, and actual known property lines were designated as such on the plot. Owners' names were inserted as encountered. Thus a somewhat crude map of each town was developed generally by two men in about two weeks. This gave a working map for a systematic search of real estate titles by title examiners, and without doubt has been of considerable value in this work.

As the ground survey of topographical features and real estate surveys have progressed, constant use has been made of the contact prints in the checking of plots of these surveys. We have all had the experience of plotting field notes with an uncertainty of the interpretation of proper connection between points located. With the contact print at hand an immediate check on such plotting can be made, thus facilitating the proper final execution of the map.

Use in Real Estate Surveys.—Party chiefs have taken the prints into the field, and by questioning local residents have gained a great deal of information as to the exact location of property lines. In a wooded country it often happens that even owners are uncertain as to their exact lines. A careful inspection of good contact prints will indicate a line of difference of timber growth of but few years, whereas on the ground no difference in growth may be observed. By calculating the azimuth of these indicated lines from lines of known location, the field party can generally, in a relatively short time, determine a somewhat difficult property line and corner. Without the data shown on the contact print similar locations might take several days of searching.

Use in Analysis of Real Estates Deeds.—The contact prints have also been of considerable assistance in the analysis of real estates deeds. In one instance a lumber operating company had released their holding by option. The tract of land had originally been made up of three parcels. Upon the checking of the deeds which conveyed these parcels there was one which could not be made to fit into the larger tract. It had been carefully drawn by metes and bounds, and but little could be found of its history. A close examination of contact prints was made in order to see if any parcel might be observed which would fit the troublesome deed. At a considerable distance away from the large tract to be conveyed was found a picture of a plot of ground which apparead to fit exactly. A field party was sent out to make a ground survey of the new area, and it was found that it did cover the deed in question. It finally developed that an early owner had held deeds for five parcels of land, one of which was included in the tract of the lumber company, and another in the parcel surveyed. It appeared that the wrong deed had been copied and unintentionally a parcel had been conveyed with no connection to the tract desired.

Temporary Suspension Bridge Carries 36-in. Pipe Line over Landslide

Emergency Measure Called for When Highway Cut Causes Slide, Endangering San Francisco's Water Supply—Work Completed in 17 Days with No Interruption of Service

By C. A. LAUENSTEIN
Assistant Engineer, Spring Valley Water Co.

CONSTRUCTION work by the state of California on the new Bay Shore Highway, from San Francisco to San Mateo, caused renewed movement of an old landslide crossed by a trestle supporting a 36-in. pipe line of the Spring Valley Water Co. In order to prevent serious damage to the line a 170-ft. suspension bridge was built as an emergency measure to span the slide. Seventeen days were required to complete the work and transfer the load from the existing trestle. During this time service was maintained without interruption.

The pipe line crossed the slide on a trestle about 300 ft. uphill from the highway. This trestle was about 130 ft. long and 10 ft. high and had bents spaced at 14-ft. intervals. It was built twenty-five or thirty years ago when movements of the slide first became evident. At that time two precautions were taken to prevent damage to the pipe line and trestle from further movement of the landslide: (1) the pipe line was equipped with lead band joints at about 25-ft. intervals and (2) the pipe line was supported on two lines of girders, each span of which was capable of carrying the load across two trestle spans, or a total of 28 ft. These girders were built up of three 8x12-in. timbers bolted together, forming an 8x36-in. member.

Plans for the new highway called for a heavy sidehill cut across the toe of this landslide. In order to prevent movement of the slide a heavy masonry retaining wall was designed. Before the wall had been completed, movement of the slide began. This was evidenced by a slight sag in the pipe line and the appearance of cracks between the retaining wall and the trestle. The main crack, which opened up about ¼ in., paralleled the trestle at the downhill edge of the bents. In order to observe further movement of the slide, stakes were driven 1 ft. on each side of the main crack and measurements taken several times daily.

Believing that further movement might occur as a result of winter rains or before the retaining wall could take the load, the company's engineers decided that some method must be devised to insure against serious damage to the 36-in. pipe line, which is a portion of a 44-in. main supply line. Such an occurrence would cut off about 50 per cent of the water conveyed into San Francisco. The only safe manner to support the pipe across the slide seemed to be a suspension bridge. In order to finish the job before the rainy season a time limit of three weeks was set.

Field work started within two days after the slide started. No time was taken in the office to investigate the proper locations for the towers or anchors. These were located according to field conditions only. The towers were spaced 170 ft. apart and the anchors located so that the slopes of the backstays would be equal. Final results showed less than 2 deg. difference in these slopes.

As brought to the office, the problem was to design a suspension bridge to fit the above-mentioned conditions, to use only materials that could be obtained without delay and to utilize the existing trestle girders as stiffeners. These were found to be in good condition and sufficiently cross-braced to act as sway-bracing. The first thing done was to make a rough analysis, using a uniform load on the 170-ft. span, to obtain an idea of the magnitude of the forces and the dimensions of the various members.

The anchors were designed to contain enough concrete to have a total weight equal to two times the cable pull and have an area sufficient to limit the earth pressure to 2,000 lb. per square foot. Each cable anchor required about 13 cu. yd. of concrete. Fortunately an existing concrete plant was available less than 600 ft. away. For fastening each cable to its anchor two 1x6-in. steel anchor bars, 20 ft. long, were embedded in the concrete. One end of each of these bars, containing an eye, was left projecting from the concrete.

Thirty-foot towers were finally selected. This height allowed for a 30-ft. total sag and made it possible to use 2-in. cable. Larger cables could not be obtained for immediate delivery. Double A-frame towers built up of four 14x14-in. timbers were designed. These were supported upon concrete piers. On top of the towers special cast-steel cable saddles were

Work on Retaining Wall and Suspension Bridge After Start of Slide. The Old Trestle Is Carrying the Load. The Highway Is in the Foreground

Bridge Complete; Scaffolding Not Removed. The Double Hanger in the Foreground Was Needed at This Girder Splice Only

placed to support the cables and eliminate sharp bends.

The total time required to pour the concrete anchors and piers and to erect the towers was about ten days. During this time the cable and the suspender connection were being designed, detailed and purchased.

From anchor to anchor the cable length was estimated as 370 ft. In ordering, however, the length was reduced 30 ft. to allow 15 ft. at each end for a set of blocks to pull the cable to the required tension. Eight strands of ⅞-in. cable wound around special sheave wheels were used for this purpose. At the anchor end the sheaves were placed around a 4¼-in. pin which passed through the eyes of the anchor bars. A special clevis was designed to connect with a 2-in. standard open socket at the end of the main cable. This consisted of two 12x24x1-in. plates set 10 in. apart, through which two 4-in. pins were passed. One pin passed through the sheaves and the other through the socket. The pipe was supported by hangers suspended from the 2-in. cables. Each of these hangers, which were spaced at 14-ft. intervals, consisted of a ⅛-in. cable fastened with clips at the lower end to the eye end of a 1¼-in. by 4-ft. threaded rod. These rods passed through 10x10-in. timbers upon which the 8x36-in. girders rested. For fastening these hangers to the main cable an inverted cable clamp was used. This was equipped with a special casting that allowed the clamp to be tightened on the cable and leave a space for the hanger and thimble.

In order to have a final sag at the center of 30 ft. it was necessary to compute the actual sag caused by loading. Rough calculations showed this to be 2 ft. The cable was therefore hung with a center sag of 28 ft. To eliminate the sag in the backstays during erection, they were supported every 30 ft. by A-frames. Transferring of the load was accomplished by screwing up on pairs of hangers in successive short rises. These rises were computed as proportional parts of the center sag. The final center sag proved to be 1 ft. greater than computed; this was probably caused by stretch in the cable and roughness of the calculations. In the meantime more accurate calculations were being made, and final adjustments were made to conform with these. Longer hanger rods were used at the six center supports and ⅞-in. cable was eliminated here, the rods being fastened directly to the cable clamp. As finally adjusted the load was uniformly distributed along the cable. The slight sag in the pipe caused by the slide was taken up to make an even grade. When loaded the cable stress was only 52,000 lb. as against a safe strength of 60,000 lb., this difference resulting from the fact that only 126 ft. of 170-ft. span, was actually loaded, whereas the design was based on a uniform load for the entire span.

During construction, observation on the main crack showed practically no movement of the slide. Thirteen days after the load had been transferred, however, the slide became active again. The total settlement of the old trestle was 10 ft., most of which occurred within 30 minutes. The cost of the construction was about $17,000.

The work was done by construction forces of the Spring Valley Water Co., in charge of T. W. Espy, assistant chief engineer. Design details were worked out by the writer, under supervision of I. E. Flaa, office engineer.

Finished Bridge Supporting Pipe. Note Subsidence of Old Trestle and Cracks in Ground. Highway Is in Left Foreground

ADVERTISING MATTER REMOVED

Some Notes on Water Works Operation

ONE of the most important features of the 1929 convention of the American Water Works Association was the session devoted to "Round Table" discussion by the superintendents and other officials. At these sessions much useful information was brought out regarding the practices in various cities. An interesting summary of these practices based on the discussions was given by J. Walter Ackerman, City Manager, Watertown, N. Y. It is reprinted here from the November Journal of the association.

Fire Hydrants Broken by Motor Vehicles.—Due to fast moving traffic with heavily loaded trucks, collisions with hydrants are bound to occur and usually result disastrously so far as the hydrant is concerned. Some times the truck or automobile goes scot free and the driver, without a conscience, leaves the place without reporting same. The question here is, "What is the remedy?" Several places report the adoption in the busiest districts of the flush hydrant, others advocate moving the hydrant away from the curb and others the placing of protective devices around the hydrant.

Meter Reading.—"In a metered system, what happens when the meter reader is unable to gain entrance to the building." In general, there is a return of the meter reader to the premises on a pick-up excursion to see if he cannot locate the family at home. If not, a return post-card is usually mailed to them with the request that they mark upon the form printed on the card the location of the dials, or if it is a straight reading register, the exact figures showing in the opening.

Depreciation Reserves.—"As to the percentage of cost used for depreciation on cast iron pipe, water station equipment, buildings, concrete floor and graveled roofs." It would appear from a review of the figures presented on this that the depreciation charges are made fairly low. As cast iron pipe is one of the principal items of expense, an examination of replies shows that it runs from one to a maximum of about 2.4 per cent, but, in general, it is evident from the reports that 1½ per cent would be about the average depreciation charge against Class "B" cast iron distribution pipe. With the other items, they vary within wide limits from 2 up to a maximum of 25 per cent for fixed assets.

Consumer's Good Will.—A practice that is altogether too uncommon is that of making a personal contact with the new consumer. One city presents a form letter which is sent out by the company to every new consumer who takes water. This creates a kindly feeling and establishes a relationship that may later help the superintendent out of any difficulty that may involve a new customer.

Collecting Water Bills.—A new method of collecting water bills is reported. That is, a city rendering quarterly bills usually has three districts, and they are sent out each month all at one time with a certain number of days allowed for payment without penalty. In the larger cities this results in over-crowding the treasurer's office on the last days for payment. To obviate that each district has sub-districts in which the date of payment is varied for every one of the sub-districts one or two days. In terms of the electrical industry that means that they have a more uniform load factor so far as collecting bills is concerned.

Shutting Off Water.—One waterworks has found a new reason for shutting off water. In a case in New Jersey it was ruled by the court that where a dog on the premises keeps the meter reader from reading the meter, the water company is justified in shutting off the service. The court said, "If the complainant (water consumer) refuses or neglects to maintain a condition at his residence admitting of regular meter readings, the company will be justified in discontinuing service and refusing to resume the supply until such condition is corrected."

Hydrant Rentals.—One of the important questions that is often asked is, "What rental do you charge the city for fire hydrants?" Unfortunately, of course, many of the municipally owned plants make no charge in the general tax levy for fire hydrant use or for general public fire protection. If this is a property benefit it should be charged against the general levy.

The maintenance of the fire department with its apparatus, building and equipment is all a general property tax and justly so, but this is but a part of the general fire protection scheme. Without the waterworks with its hydrants, its enlarged mains and works, the personnel of the fire department would be unable to render any service. There should always be a charge, therefore, in the general city tax levy for the use of the fire hydrants and the mains, etc. The general question is, how much or in what manner shall the amount be computed. From the replies appended and from the opinion of those who have helped to make our manual of practice a model and guide, it seems to point directly to two factors; one, the number of standard hydrants and the other the inch feet of mains. While the amounts may vary the principle is the same. The gross amount allocated to public fire protection should be determined. The rates should then be proportioned to the amount of inch feet of mains and the hydrants so as to yield the required sum.

Waterworks Forms and Their Use.—The systematizing of all sorts of control accounting for widely different purposes has developed immensely within a decade. In waterworks operation, while progress has been made to some extent, the same advance has not been made that we find in other lines of business activities. Such articles as we find on the development of different systems of bookkeeping and detail will be of great advantage for study in order that accounting control and information may be made available.

Tapping Mains.—"What is the practice with regard to tapping of mains for various size services from ¾ to 3 in.?" It would appear that the trend of practice is to use a wet tapping machine from ¾ to 1 in. and with larger sizes to cut in a tee or use a tapping sleeve and valve.

Frozen Service Pipes.—In the colder climates, the question of frozen service pipes is always a bothersome matter because the customer who is unfortunate enough thinks he is being discriminated if he finds that his service is frozen and that of his neighbor is still free from the frost. Of course, the reason for frozen services is that they are laid in too shallow trenches and modern snow removal practice makes for greater exposure. In our northern latitudes like Watertown we cover mains and services at least 5 ft. This does not always protect us, however, and during some winters the extreme cold will render large numbers of services impossible of use without thawing. The best general practice at the present time is in the use of one of the small machines operating under its own power and developing current of a proper strength to thaw out the services running into the houses. This is much better practice than the old method of hot water and a pipe line inside of the service pipe. Unless the pipe was laid in exact line or level it was usually difficult to secure proper results with the hot water, whereas, with electricity, it takes but a few minutes to thaw a frozen pipe sufficient to start the water.

The freezing of the service pipe sometimes involves the meter as well. Practice dictates that the necessary repair in such a case should be borne by the user or owner of the building.

Meter Setting and Ownership.—Pursuing the meter subject further, not much is found as to practice of owning and setting meters. However, it is generally conceded that ownership should be vested in the waterworks and the waterworks with its own employees should make the settings, first, because of their proper interest in determining the best location in complicated cases and to be sure that all water used should pass through same, and secondly, it can be done at a much lower figure than by plumbers. In a

recent experience in my own city, the cost of installing about 2,000 ⅝-in. meters averaged $1.90 per meter, covering all expenses therefore, as follows:

Fittings, including labor cost of cutting threads on piping	$0.67
Labor cost, testing and sealing meters	.09
Labor cost installing, including time of foreman, assigning work and checking, material and installation	1.14
Total	$1.90

The only item not charged for was use of service truck for foreman. The wages paid the general foreman were 60 cents. Each meter setter was paid 55 cents and each meter setter's helper was paid 50 cents. The average number of meters set each day by each crew of two men was 7.6 in 8 hours.

We call our waterworks a "utility," and first of all it should be utilitarian. Unfortunately, in too many cases it never gets beyond that point, as in general the funds available are all needed for the basic requirements. There seems to be an increased interest in the possible aesthetic values inherent in the building of, or the later development of, the works. Landscaping of the grounds can be accomplished with small outlay, keeping storehouses and yards in a neat condition. All these factors tend to impress upon the public that this quality extends to the product as well. In some places where it is necessary to have elevated water towers they should be made artistic to conform with the surroundings.

The interior of filter plants and pumping stations should be kept in the most clean and orderly way. Even the much criticised polished brass has a wholesome effect, not only on the public but on employees, for in some instances it is almost necessary to provide some such detail to keep an employee busy.

Well Drillers to Meet.—The American Association of Water Well Drillers will hold its convention in conjunction with the Minnesota Well Drillers' Association, at the Twin Cities, Feb. 4, 5, and 6, 1930. Delegates from eight states will be present. An attendance of about 400 is expected. Meetings will be held in the Engineering Building, University Farm, Midway, St. Paul, Minn. The National Council, including representatives of each state drillers' association, engineers, geologists, manufacturers, the National Research Council, and the U. S. Geological Survey, will consider such questions as drilling standards and ethics, specifications for wells, equipment standards, etc. Drillers, engineers, and others interested in water supply are invited to attend the open meetings of the convention. M. J. Spencer, Granada, Minn., is president.

Chloro-Phenol Tastes in Water Supplies from Ohio River

In connection with studies of stream pollution, it has been found by the U. S. Public Health Service that for several years past, and particularly since the war, tastes and odors of such a nature as to identify them with the presence of phenols and allied substances have been experienced, with varying frequencies, in the water supplies of cities located on the inland waterway systems of the middle western and eastern portions of the United States. Tastes of a similar nature have appeared in water supplies located in other areas, both of this country and of Europe. In no instance, however, has this difficulty been more serious or affected larger groups of population than it has in the area adjoining and tributary to the upper portion of the Ohio River, which drains a highly industrialized region serving as a center of the coal, steel, and allied industries.

A search for the specific causes of the tastes and odors above described revealed the fact that during and since the war period the coke-producing industry has been abandoning the use of the older "beehive" ovens for burning coke and has been sustituting for them modern by-product plants, from which valuable substances are recovered from the gases which formerly went to waste in the atmosphere. The residues from some of these recovery processes, notably those concerned with the manufacture of benzol and ammonia, have been found to contain very considerable amounts of tar, phenols, creosols, creosotes, and similar substances, which, when discharged into sources of water supplies, produce characteristic "medicinal" tastes and odors in them. Although other classes of wastes, notably those derived from producer-gas plants, have been found to contain phenols and similar taste-producing substances, the total amounts of phenols resulting from the operation of coke by-product plants are so much greater than those produced by any other single industry, and their production takes place in such highly concentrated areas, that a large share of the responsibility for the difficulties caused by wastes of this class logically has been attributed to them.

Recent studies by other workers have shown that the oxidation of phenols, which can be accomplished by ordinary biological processes of sewage treatment when phenolic wastes are mixed in proper proportions with sewage, is essentially a biochemical phenomenon, proceeding along definite time-function curves at rates varying closely with the temperature, being greater at higher temperatures, and vice versa. As the behavior of phenols in the Ohio River has been consistent, except in degree, with their reactions to artificial processes of oxidation, it would seem quite logical to infer that the progressive reductions thus observed under natural conditions may be due to a process of natural biochemical oxidation similar, in its general characteristics, to that which proceeds more intensively under artificial conditions.

If the foregoing theory is correct, its lesson is fairly obvious in so far as its application to problems involving the elimination of sources of phenol pollution of water supplies is concerned. In cases in which water supplies are subject to continuous or frequent pollution by phenols, the important sources of such pollution are more likely to be found in the near vicinity of the supply than at any considerable distance. If, however, they are subject only to occasional pollution, occurring more especially during the colder season, or in streams, coincidently with high river stages, the source of the trouble probably is located at a more distant point. In undertaking any general program of remedial measures looking to the relief of phenol pollution of water supplies, located along an entire stream, the maximum immediate benefit of such measures probably will be attained by eliminating, first, all sources of phenol pollution located directly on the stream in question or in the lower reaches of tributaries discharging into the main stream above the points at which the water supplies affected are located. The history of phenol tastes in Ohio River water supplies, both during and following the institution of progressive remedial measures by the bordering states, has afforded an interesting confirmation of the principle stated.

The effectiveness with which the pollution of Ohio River water supplies by phenol wastes has been brought under a large measure of control within the comparatively short period of time intervening since the year 1925, constitutes one of the brightest pages in recent sanitary history. Accomplished, as it has been, without any coercive legislation, but through cooperative effort by the Federal and state governments and the industries concerned, it augurs well for the future solution of some of the larger problems of stream pollution now confronting the nation. Although pollution of the Ohio River system by wastes has not been completely eliminated, as evidenced by occasional "spills" which have occurred during the past year or two, it has been curbed to an extent such as to justify the expectation that in the near future it will cease to be a major problem along this important waterway. A generous measure of credit is due to those whose joint efforts have brought about this fortunate result.

Water Supply for Los Angeles from High Sierras

By WALTER A. GILLETTE

IN former articles on the Colorado River Boulder Dam Project I have questioned the advisability of carrying through such a project at any time, or for some years to come at least. My opinions have been based on general engineering and structural knowledge, aided by a good idea of the topography of the High Sierras.

Recently I made some sketches of the territory drained by six of the large basins, namely, Owens River, Bishop Creek, Owens Lake, Mono Lake, East Walker River and West Walker River, all within the state of California. This study has shown conclusively that a large additional quantity of water can be easily diverted for use in the Metropolitan Water District of Los Angeles.

I have taken my data from several authentic sources, such as the California State Engineers Report, Bulletin No. 5, "Flow in California Streams," and from a bulletin containing papers read last June before the University of Southern California, under the title "Water Papers," and from the report of Los Angeles City Department of Power and Water.

Owens River Basin.—The California Engineers' report shows that the Owens River Basin has 524 square miles drainage area, which produces a mean run-off of 278,000 acre-feet, equal to 281 second-feet, which, based on 5,000 people served per second-foot (the figure used by the Los Angeles City Water engineers as being sufficient for domestic and industrial purposes, but does not include farm irrigation) would supply 1,405,000 people. It is well to state at this point, that as these figures are the mean run-off, that probably not more than 50 per cent of the amount given can be conserved by the use of reservoirs.

Bishop Creek has 446 square miles area, producing 341,500 acre feet, or 468 second feet, supplying 2,340,000 people. Owens Lake has 216 square miles area, producing 83,000 acre feet, supplying 570,000 people, or a total of 863 second feet, which multiplied by 5,000 would serve 4,315,000 people; but, as I stated above, it will hardly be safe to figure on more than half these figures, therefore we get 431 second feet, serving 2,157,000 people, almost all of which can be carried by the existing aqueduct, for its capacity is 400 second feet.

The City Engineer's report shows 540 second feet now available in the local area of the Metropolitan Water District, without the Owens River supply, therefore the local water supply, plus the 400 second feet from the present aqueduct, is 940 second feet, which will serve 4,700,000 people. It is quite apparent that less than half this amount is being used for domestic and industrial purposes, for the present population is only 2,350,000 people.

By a deduction from data published by the Board of Water and Power, I find that about 36 per cent of the Los Angeles aqueduct is being used for irrigation. This would supply a city of 600,000 people.

It is evident that not all of the water in the three basins, in what I will term Owens Valley, is being conserved, which indicates that a large storage reservoir, such as the one proposed at Long Valley, at the head waters of the Owens River, is vitally necessary and should be built at once.

Assuming that the figures of the Los Angeles engineers are correct, it is clear that they show water enough for twice the population now in the Metropolitan Water district without looking further, provided that none of it is used for irrigation or is wasted.

Mono Lake Basin.—However, as we proceed, other interesting developments unfold. Mono Lake Basin shows 166 square miles drainage area, with 215,650 acre-feet run off, being 282 second-feet, one-half of which can be stored and diverted, which will serve 700,000 people. Just beyond Mono Lake we come to the East Walker River Basin, with 411 square miles area, with 312,300 acre-feet run off, or 428 second-feet; one-half can be conserved and will supply 1,075,000 people.

Running parallel to East Walker and a short distance northwest, is the West Fork of Walker River, 450 square miles drainage area, giving a run off of 313,800 acre-feet or 430 second feet, one-half to be conserved can furnish another 1,075,000 people. These figures give us water for 2,850,000 people, which when added to the 4,700,000, makes 7,550,000 people. When will the need arise for that amount of water?

An exceedingly advantageous point about the development of these drainage basins is that they can be developed as the needs demand. My rough estimate is that the six basins enumerated can be developed, including land purchase and damage to small farms, for not to exceed $100,000,000 cost.

After deducting a prorated sum for power not used in pumping water from the total estimated cost of the Colorado River project, there remains about $400,000,000 for developing 1,500 second-feet of water from that source. Bear in mind at all times that after this proposed Colorado River expenditure, the plant will be saddled with a perpetual pumping cost to lift the entire volume used, 1,600 ft. Whereas only a part of the water from Walker River basin need be pumped, and that with a lift not exceeding 1,000 ft.

Ease of Development.—One of the most attractive features of this High Sierra layout, aside from extreme economy as compared with any other, is that each of five units can be developed as needed, which I would place in the following order: (1) develop all water in the Metropolitan Water District, (2) develop all water in the Owens River basin, (3) develop and divert all water in the Mono Lake basin, (4) develop all water in the East Walker River basin, (5) develop all water in the West Walker River basin.

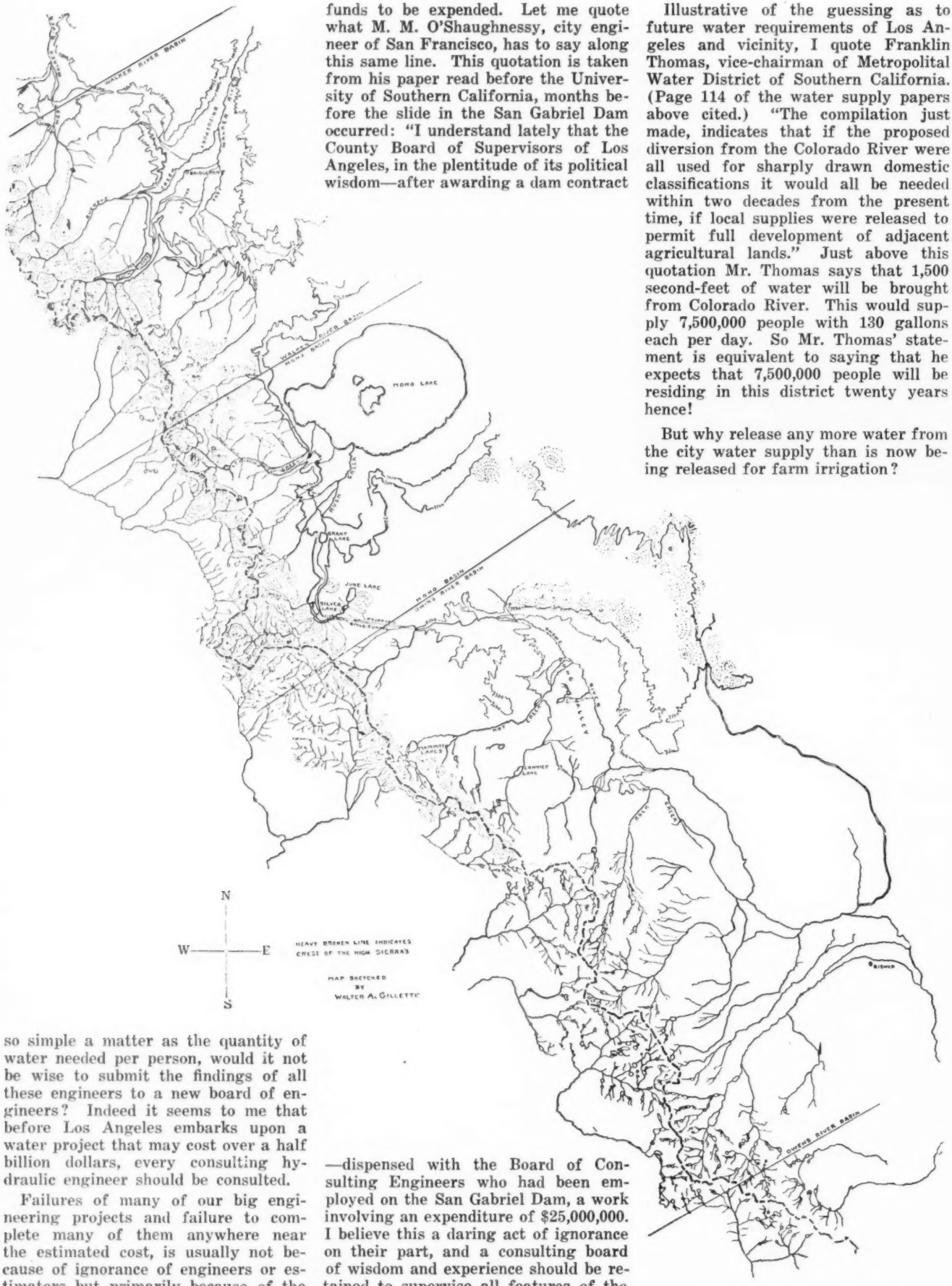
In this entire group there is not a single difficult problem; in fact the whole layout is so simple that no engineer, by its development, could leave much of monument to the glory of his ability. It is perfectly natural that any engineer should wish to be a party to so collosal a construction as the Boulder Dam. Granting the right to any man to be ambitious, I see no reason why the taxpayers should paint any engineers' names in wasted gold on the cliffs of the Colorado River.

Engineers Disagree.—There seems to be no unanimity of opinion among engineers as to the amount of water needed by Los Angeles and vicinity. For example, the Consulting Board, composed of Hill, Lippencott, and Sonnderegger (page 112 of papers read last June, University of Southern California) show 130 gallons per capita per diem for domestic use, plus about 30 gal. for industrial use, total 160 gallons per capita per diem for Los Angeles urban territory.

E. A. Bailey, of the Los Angeles Water and Power Department, allows 5,000 people per second-foot which is equivalent to about 130 gal. per capita per diem. Statistics show that the city of Detroit uses 125 gal. per capita per diem. And the city of Milwaukee uses about 100 gal.; I was going to suggest that must be because of their beer; but it takes water for beer, so that can't be the reason. M. M. O'Shaughnessy, city engineer of San Francisco, who has charge of the Hetch Hetchey water development, estimates 100 gal. per capita per diem, and he states that his city employed several boards of independent engineers to pass on all their problems.

Average Water Consumption.—As I looked up figures on the per capita use of water in American cities I thought at first glance, that the big spread was because of some peculiar locality, yet San Francisco's use of 100 gal. per person daily, shows that such is not the case. So when we see a spread of 60 per cent in the estimated per capita use of water, among engineers of high standing, we are apt to ask ourselves this:

If these engineers do not agree on



Location of Basins in High Sierra Region Capable of Supplying Water Sufficient for 7,500,000 People

so simple a matter as the quantity of water needed per person, would it not be wise to submit the findings of all these engineers to a new board of engineers? Indeed it seems to me that before Los Angeles embarks upon a water project that may cost over a half billion dollars, every consulting hydraulic engineer should be consulted.

Failures of many of our big engineering projects and failure to complete many of them anywhere near the estimated cost, is usually not because of ignorance of engineers or estimators but primarily because of the penny-wise and pound-foolish practice of the political heads in charge of the funds to be expended. Let me quote what M. M. O'Shaughnessy, city engineer of San Francisco, has to say along this same line. This quotation is taken from his paper read before the University of Southern California, months before the slide in the San Gabriel Dam occurred: "I understand lately that the County Board of Supervisors of Los Angeles, in the plentitude of its political wisdom—after awarding a dam contract —dispensed with the Board of Consulting Engineers who had been employed on the San Gabriel Dam, a work involving an expenditure of $25,000,000. I believe this a daring act of ignorance on their part, and a consulting board of wisdom and experience should be retained to supervise all features of the construction of this extraordinary large project."

Illustrative of the guessing as to future water requirements of Los Angeles and vicinity, I quote Franklin Thomas, vice-chairman of Metropolital Water District of Southern California. (Page 114 of the water supply papers above cited.) "The compilation just made, indicates that if the proposed diversion from the Colorado River were all used for sharply drawn domestic classifications it would all be needed within two decades from the present time, if local supplies were released to permit full development of adjacent agricultural lands." Just above this quotation Mr. Thomas says that 1,500 second-feet of water will be brought from Colorado River. This would supply 7,500,000 people with 130 gallons each per day. So Mr. Thomas' statement is equivalent to saying that he expects that 7,500,000 people will be residing in this district twenty years hence!

But why release any more water from the city water supply than is now being released for farm irrigation?

The Winston-Salem Sewage Treatment Plant with the Clarifiers in the Foreground

The Chemical and Mechanical Sewage Treatment Plant at Winston-Salem, N. C.

Biological Processes Discouraged in This Unusual Plant—Electrolytic Method Applied Successfully to a Strong Sewage—Satisfactory Effluent and Sludge Secured at Reasonable Cost

By CHARLES M. NELSON
Associate Editor, Water Works and Sewerage

THE sewage treatment plant at Winston-Salem, N. C., is remarkable for its design and for the success with which it is solving the sewage problem of the city. It is a chemical and mechanical sewage works, the units of which were assembled to meet the peculiar needs of Winston-Salem. As far as known, it is unique in the combination of processes employed. Since the plant went into operation in December, 1926, it has given consistently a satisfactory effluent and an easily-disposed-of sludge at a cost considerably below the estimated cost of other types of treatment. The notes presented here are based upon an inspection of the plant made in September, 1929.

The Sewage Problem at Winston-Salem

Winston-Salem has a population of 85,000; the population connected to the sanitary sewer system is about 75,000. The sewer system is of the separate type. The present flow is about 5.5 m.g.d., or about 73 gal. per capita per day.

The sewage of the city is of a particularly strong and disagreeable nature. Total solids are in excess of 1,000 p.p.m. The grease content ranges from 65 to 70 p.p.m. The raw sewage occasionally has a trace, but usually there is an entire absence, of dissolved oxygen when it reaches the plant. The treatment problem is complicated by the presence of industrial wastes, resulting from the manufacture of cigarettes and tobacco, textiles, furniture and dyes.

The design of the present plant was undertaken when the nuisance caused by a septic tank which had served the city for some years, became too great to continue this mode of disposal. The present plant is situated at the site of the old septic tank on a small stream southwest of the city, a little more than two miles from the central section. The flow of the creek ultimately reaches the Yadkin River about 11 miles below the plant. In a dry season the flow is frequently less than the flow of effluent from the plant.

In contemplating methods of treatment, a plant employing biological processes was looked upon with disfavor, principally for the reason that such a strong, difficult sewage was being dealt with. A scheme was sought by means of which the raw sewage might be turned into stable products as quickly as possible; the answer was found in a chemical and mechanical plant, not dependent for its results upon any form of bacterial activity. Immediate removal of coarse, obnoxious

solids is practiced and conversion of the remaining materials into stable compounds is accomplished by electrolysis of the sewage, rendered caustic by the application of lime.

Units Comprising Plant.—The essential units comprising the plant are shown diagrammatically in Fig. 1. The raw sewage passes through a bar screen and Detritors, to revolving-drum fine screens. From the screens the sewage passes to a lime-dosage tank and thence to a battery of electrolyzers. Clarifiers, sludge pumps, a secondary thickener, sludge filters and an outfall pump complete the apparatus. The plant is operated electrically, power coming from the city. The plant is equipped with a gasoline-engine-driven generator for emergency use. These units are considered in detail in the following sections.

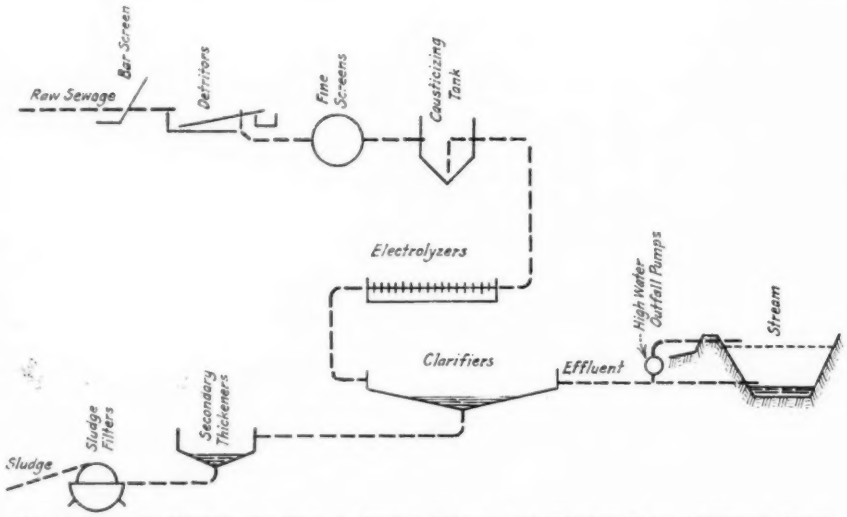


Fig. 1—Diagram Showing the Flow of Sewage Through the Winston-Salem Treatment Plant

Coarse and Fine Screening

The sewage of Winston-Salem is collected in several long gravity trunk sewers which converge above the plant. Screening is accomplished by a bar rack, grit chambers or Detritors and revolving fine screens.

Coarse Screening.—The bar screen is of the Dorr mechanically-cleaned type. For a period of time when the plant was first put into operation, the screen was cleaned by hand raking; this, however, was found undesirable as the loss of head caused by the accumulation of coarse material on the rack resulted in a variable flow—a disadvantage from the standpoint of subsequent processes. A further advantage is the elimination of the part-time services of one employee. The screenings are disposed of in the municipal incinerator plant.

Grit Chambers.—Dorr Detritors (see "Municipal News and Water Works," Feb., 1929, p. 81) in duplicate provide for the removal of grit. A high percentage of grit recovery is desirable in a mechanical plant, as the presence of grit might be expected to have some harmful effect upon the plant mechanism. The collecting tanks are 18 ft. square and the collecting mechanism of each unit is driven by a 1-hp. electric motor. Cleaning channels are 1¼ ft. wide and 28 ft. long. The cleaning rakes are driven by 2-hp. motors. The maximum capacity of the Detritors is 9 m.g.d. each.

The average total organic content of the grit recovered is less than 5 per cent. The grit is used for building roads about the plant. Figure 2 is a picture of the bar screen and the Detritors. Since the time this photograph was taken, a housing has been erected over the bar screen and the connecting walkway.

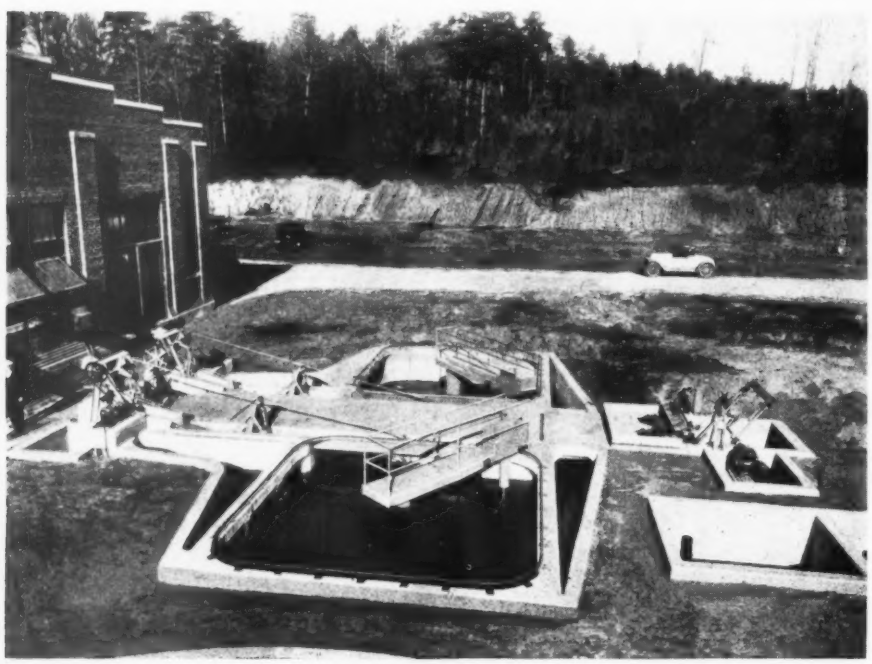


Fig. 2—Bar Screen and Detritors. A Housing Over the Bar Screen and Connecting Walkway Has Been Built Since This Picture Was Taken

Fine Screens.—Fine screening is accomplished by two Dorrco revolving screens of the self-cleaning type. Screenings are disposed of at the municipal refuse plant, along with the screenings from the bar rack. The fine screens are cleaned of grease about once a month.

Electrolytic Treatment

The electrolytic treatment as yet is not completely defined as many reactions taking place are unknown, but research work is disclosing daily hitherto unknown interesting and instructive characteristics regarding the variety of reactions taking place in the electrolyzers. It is established definitely that nascent or atomic oxygen is developed, as well as hydrogen through the electrolysis of lime water. The reaction here is swift and selective, since in the atomic state the oxygen is avid for reaction, as are likewise the most putrescible or unstable matters in the sewage. This results in immediate stabilization of the most highly putrescible matters. This is indicated by the complete and immediate removal of odors, which does not take place when the electrolyzers are by-passed. It is also definitely established that there is a distinct aid given to subsequent sedimentation through a change in the charges on the ionized materials as explained by the colloid theories. Probably the most important reactions and yet the least definitely known are the electrolytic actions in forming completely different compounds as a result of energy supplied by the electric current passing through the sewage. Certain it is that obnoxious odors and gases are gone as soon as the electrolytic action has taken place and that all processes following electrolytic action deal with practically stable materials.

During the electrolytic action there is deposited on the electrode plates a film of calcium carbonate, rendering the electrodes passive and preventing

the loss of the material constituting the plates which would take place if the sewage were not first rendered caustic. Mechanical agitators or scrapers are provided for the purposes of removing grit and film from the electrodes, preventing polarization and insuring intimate contact of the sewage with the electrodes. The equipment used for the alkalinization of the sewage and the electrolysis of the lime-sewage mixture consists of tanks for the preparation of the lime solution, apparatus for controlling the lime dosage, a mixing tank and the electrolyzers.

Solution Tanks.—Tennessee quicklime is stored in bulk and slaked at the plant. A 3 per cent milk of lime is made up, effluent from the outfall being used in place of fresh water. The solution is piped to the dosage-control apparatus at scouring velocity in order to prevent encrustation of the pipes. The flow required to prevent loss of diameter is in excess of the amount required for admixture with the sewage.

Control of Dosage.—The sewage is metered by a General Electric flow meter as it passes from the fine screens. Milk of lime is now admitted to the sewage through the dosage apparatus to give a causticity of 50 p.p.m. This apparatus, which is illustrated in Fig. 3, consists of a Leeds & Northrup controller and a motor-operated tilting weir box.

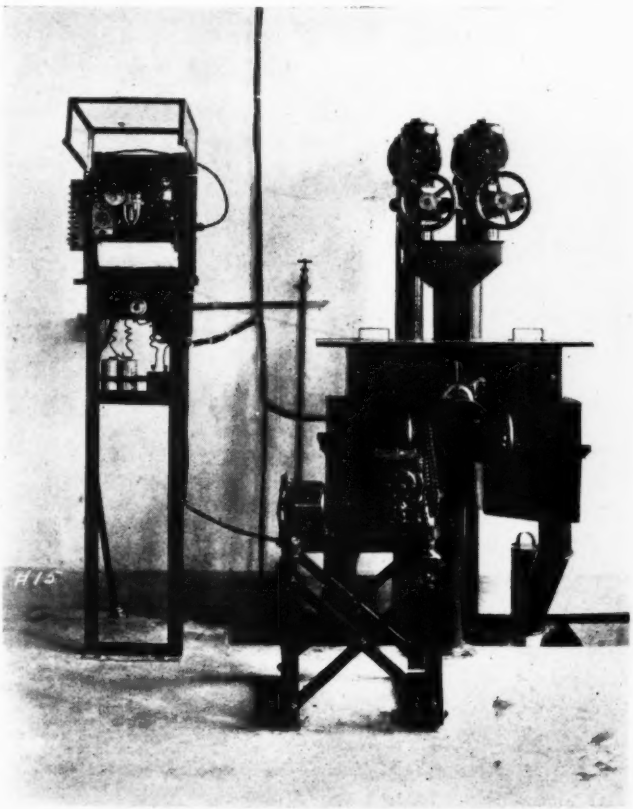
Milk of lime in excess of the maximum sewage demand is admitted uniformly to the central compartment of the weir box, which contains overflow weirs at each end. The flow over one weir is returned by gravity to the lime solution tank, and that from the other weir is applied to the sewage prior to its entrance to the reaction or causticizing tank. When the box is horizontal the flow of lime solution is evenly divided; any change from the horizontal position alters the elevations of the two weir crests and thus regulates the lime dosage. The position of the box is governed by the controller, which is actuated by the potential created between a tungsten electrode and a calomel half-cell immersed in the sewage at a point downstream from the lime application. This potential is a function of the hydroxyl-ion concentration of the limed sewage and its variation indicates a change in the lime demand of the sewage. Thus, by converting the variations in potential into corresponding movements, as regards both degree and direction, of a contact cam in the weir-box motor circuit whereby the position of the box is regulated, lime is applied to the sewage in accordance with the demand.

Causticizing Tank.—Thorough mixture of the lime solution and the sewage is secured in the causticizing tank, which is a circular concrete tank with a conical bottom. The sewage enters tangentially and is siphoned off from the bottom of the tank. From the tank it flows to the electrolyzers.

Electrolyzers.—The lime-sewage mixture passes over equalizing weirs to four electrolyzers. Space remains for a fifth unit, in which an experimental cell of 1-m.g.d. capacity is now installed. Figure 4 shows one of the four units with the covers removed, and Fig. 5 is an early view of the plant with only two units in place. Each electrolyzer has a normal capacity of 3 m.g.d., giving the present equipment a total capacity of 13 m.g.d.

Each of the four concrete tanks contains 18 rows of 90 vertical iron plates. The plates are 25x16 in. in size and are spaced ⅜ in. apart. Direct current is supplied from motor-generator sets at approximately 35 volts and from 125 to 150 amp. The 18 tanks are connected in series and the 90 plates in each row are placed in parallel, the plates being alternately positive and negative; thus the drop between plates is about 2.0 volts. Pyralin scrapers, in contact with the surfaces of the plates, are driven from below by a crank-and-connecting-rod gear. The tanks are covered with removable covers, which allows cleaning of the plates by hand when necessary. This is done once a month. The plates have an estimated life of three years. The lime and electrolytic equipment was installed by the Direct Oxidation Process Corp., of Philadelphia, Pa.

Experimental Electrolyzer.—A new type of electrolytic cell is now being demonstrated at the Winston-Salem plant, utilizing hydraulic cylinders in place of the crank-and-connecting-rod gear for the operation of the scrapers or depolarizers. The dimensions of the electrodes and the length of the scraper travel have been so increased that one



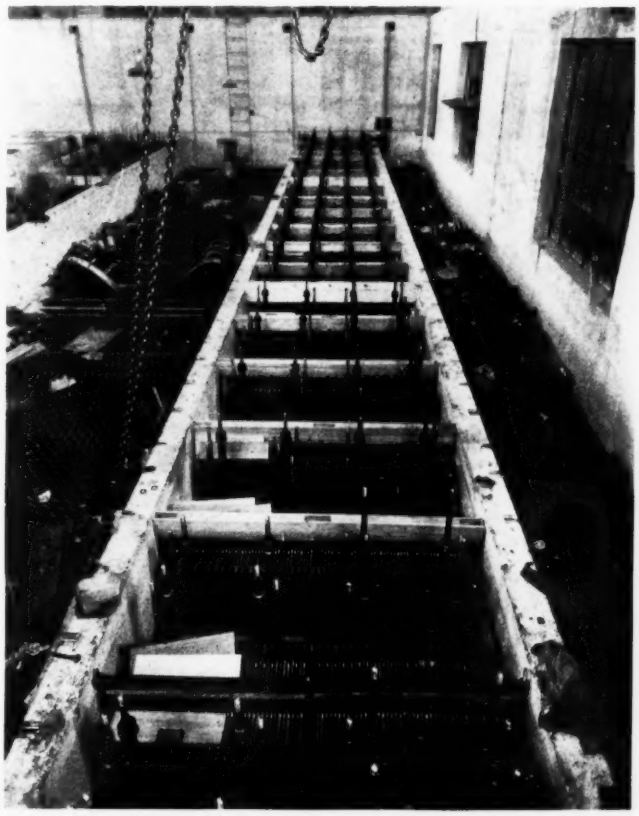


Fig. 3 (Left)—Lime-Dosage Control, Showing Tilting Weir Box at Right; Fig. 4 (Right)—One of the Electrolyzer Units with Cover Removed

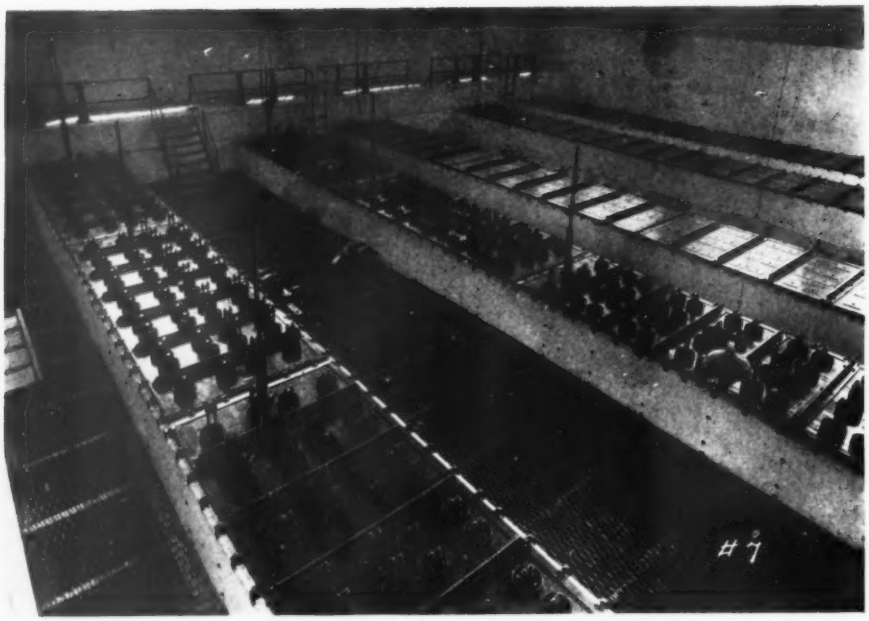


Fig. 5—The Electrolyzer Room at Winston-Salem. Two Additional Batteries and an Experimental Cell Have Been Since Installed

bank of electrodes is equivalent to six banks of the former design, resulting in a net decrease of about 80 per cent in the number of moving parts required for the actuation of the scrapers for a given treatment capacity. As a result of the increased plate dimensions and the consequent reduction in the number of plates, the hydraulic operating head has been reduced to but a fraction of that required for the under-driven cell, and the overall length of a unit of given capacity has been reduced some 30 per cent. In spite of this reduction, the new cell has larger clear spaces between consecutive banks of electrodes. This facilitates internal examination and maintenance. The electrical energy is supplied by low-voltage generators. This eliminates the stray currents experienced with older designs in which a large number of relatively small banks of electrodes were connected in series across the terminals of a high-voltage generator, and reduces the corrosive effect on the internal parts of the equipment with consequent savings in maintenance and repair. The entire actuating mechanism is placed above the cell, making it more accessible and reducing the cost of installation of this type of electrolyzer. It is anticipated that the new type of cell will be substituted for the units first installed as soon as replacement becomes necessary.

Sedimentation and Filtration

From the electrolyzers, the sewage flows to two clarifiers, from which the effluent passes to the stream and the slurry to a secondary thickener and, finally, sludge filters.

Clarifiers.—Sedimentation equipment comprises two rectangular Dorr clarifiers. The theoretical detention period for a 9-m.g.d. flow is one hour. At the present rate of 5.5 m.g.d. the detention period averages three hours. American Well Works pumps are provided for raising the level of the outfall at times of high water. Some of the effluent is used at the plant for making up the lime solution and, raised to a high pressure, for cleaning out the clarifiers. The slurry, which has a moisture content of about 95 per cent, is pumped by Dorr sludge pumps to a secondary thickener.

Thickener.—The moisture content of the sludge is reduced to about 88 per cent in a circular Dorr thickener, 50 ft. in diameter. Lime is added to the sludge after thickening, just before filtration. When operation was first begun, the sludge was not conditioned with lime and it was found that the considerable grease content of the sludge interfered with subsequent filtration; with the addition of lime, however, this fault was done away with.

Sludge Filters.—Sludge is filtered in two vacuum-drum filters, manufactured by the Filtration Engineers, Inc. The filters are fed from the thickeners by a pump, the overflow from the filters draining back to the thickeners by gravity. The capacity of the pump is slightly in excess of the capacity of the filters, so that there is always a rising current in the sludge reservoir beneath the filters.

Each filter consists of a drum 8 ft. 6 in. in diameter and 8 ft. long, rotating on a horizontal axis. The lower part of the drum dips into a tank containing the sludge. The drum is made of heavy sheet steel, divided by longitudinal members spaced approximately 1 ft. apart; thus each 1-ft. strip around the circumference forms a separate filter. The steel drum between the division members forms a drainage compartment. Openwork hose duck is stretched around the entire drum to protect the filter cloth from mechanical wear against the drainage members. The filter cloth is sealed in the division members and around the edges of the drum so that each compartment is a separate filter unit.

A pipe leads from each compartment to a control valve, which consists of a rotating hub into which all the pipes are assembled. As the hub rotates, each pipe coincides momentarily with ports in a stationary collecting ring surrounding the hub. As a compartment dips into the sludge reservoir, a vacuum is created within the compartment, with the result that the liquor is pulled through the filter cloth, leaving the solids on the outside. As the compartment leaves the reservoir, the suction within is increased and the moisture content of the solids deposited on the filter cloth is reduced appreciably. The sludge cake is released by admitting air under atmospheric pressure to the compartment when the point of discharge has been reached.

The sludge cake, which varies from ¼ to ½ in. in thickness, is peeled from the drum by cords. The moisture content of the sludge averages from 60 to 66 per cent. Sludge is produced at the rate of about 30 tons a day. As the sludge comes from the drums it is elevated to a hopper by belt conveyors.

Final disposal of the sludge is made in a near-by field having an area of approximately 20 acres. The sludge is drawn out by a mule team and dump wagon. The sludge is allowed to dry on the ground for a period of from 2 to 4 weeks and is then disked over with a harrow to open it up and further the drying process. Up to the present time three or more layers of sludge have been deposited over the area of the field.

Adaptability to the mechanical system of sewage treatment and to variable conditions met from day to day are features of this sludge-filtering installation. The solids are separated out readily, and the moisture content of the sludge cake is exceedingly low. The string discharge method eliminates any reversal of current to lift the cake from the filter cloth, with the result that no portion of the filtrate lying in the drainage system is blown back into the discharged cake. This assures the maximum moisture reduction. Another important element is the use of a very cheap grade of filter cloth which will not plug up, but will wear out in about three weeks' operation; thus a prime filtering condition is maintained at all times.

Results of Treatment

Aside from considerations of cost, the success with which the plant is performing its work may be judged by the ability to dispose of its products without nuisance and the degree to which the plant itself is offensive to surrounding inhabitants. One of the things that impresses a visitor to the Winston-Salem plant most is the freedom from

disagreeable odors all through and about the works, the only exception being a small area about the bar screen and Detritors, where the raw sewage is received. A strong and not unpleasant odor of lime pervades the slaking and sludge-filter rooms and, to a lesser extent, the electrolyzer room. Offensive odors are apparently killed as soon as the electrolysis is begun. The absence of hydrogen sulphide is attested by the freedom of the copper bus-bars and knife switches on the panels controlling the motor-generator sets from any deposit of sulphide.

Effluent. — Characteristics of the treatment are a high removal of dissolved and suspended organic matter and an increase in dissolved-oxygen content from nearly nothing to a figure approaching that of the stream in which final disposal is made. The organic compounds in the effluent are largely stable. In appearance, the effluent is not especially clear, being in this respect probably not as good as activated-sludge effluent. Discoloration is caused by dye wastes, and the cloudiness of the effluent results from the presence of calcium carbonate, which probably accounts for about 50 per cent of the suspended solids. Further clarification could be accomplished by additional processes if there were any need for this.

The plant is provided with a chemical laboratory and is under chemical control. While the regular routine analyses are made, presumptive tests are not relied upon to furnish indices of the quality of effluent secured. In place of such tests, a thorough sanitary survey of the stream carrying the effluent is made once a month, about and for a considerable distance below the outfall. The survey includes physical, chemical, biological and bacteriological tests of the stream. The examination of the creek is conducted by the plant chemist and the engineer in charge, in a canoe.

As a result of these periodic analyses it has been established that there are no desposits of sludge in the bed of the stream and that there is no evidence of gassing or anaerobic decomposition. There are no offensive odors; indeed, the only odor given off by the effluent is the characteristic lime odor found at the clarifiers and outfall. Organisms which might indicate pollution are absent. The dissolved-oxygen content of the stream is restored to normal within a few miles below the outfall. These results are not confined to any particular season, but are secured throughout the year—even during the extreme summer heat and in the dry month of September, when the flow of the creek is at times less than the quantity of effluent discharged. From the examination of the stream it may be stated definitely that a thoroughly satisfactory, non-septic effluent is being secured.

Sludge.—Equally satisfactory is the quality of sludge resulting from the treatment. The cake has the odor of lime as it comes from the filter drums. It contains about 50 per cent calcium carbonate and for this reason is more bulky than the sludge ordinarily obtained from biological treatment processes. The sludge dries easily. It is a stable product and it remains stable under all conditions. The area on which it is deposited is low, marshy ground, frequently inundated by overflow of the stream into which the effluent flows. In spite of this, there is no period of the year when offensive odors or nuisance of any sort can be detected.

While no attempts to market the sludge have been made, it obviously possesses value as a fertilizer. Corn from 12 to 14 ft. in height was observed growing on the disposal tract late in September. Experiments are under way, however, to determine if it is economically feasible to recover the lime by burning the oxidizable content of the sludge. If it is found cheaper to recover the lime in this fashion than to buy lime, this step will be taken and sludge will no longer be wasted.

Cost of Treatment

The present plant, which is capable of treating a flow of 13 m.g.d., was built at a cost of $650,000. It is estimated that the capacity can be increased to 15 m.g.d. by the expenditure of an additional $75,000. The cost of the plant is considerably below the estimated cost of any of several types of biological plant considered.

Operating Cost.—The cost of treatment is at present $25.88 per million gallons, based on the present actual flow of 5.5 m.g.d. The cost of operation may be itemized as follows:

Salaries and labor	$ 9.04
Lime	6.79
Power	2.64
Current for electrolysis	0.80
Repairs and replacements	3.56
Supplies	1.64
Miscellaneous	1.41
Total	$25.88

This is equivalent to about 69 ct. per capita of connected population per annum.

The operating cost given does not include cost of capitalization. Based on a charge of 7 per cent, this reduces to $9.59 per million gallons. Since certain items of operating cost will not increase with an increase in flow, the unit operating cost may be expected to decrease as the population of the city increases. It may be noted that the cost of treatment at Winston-Salem does not suffer by comparison with operating costs where other processes are employed under similar conditions.

The Winston-Salem treatment plant was designed by Harry L. Shaner, commissioner of public works. W. E. Thrasher, engineer of operations and maintenance, is in charge of the plant. R. M. Rodgers is plant chemist and M. O'Shea is plant superintendent.

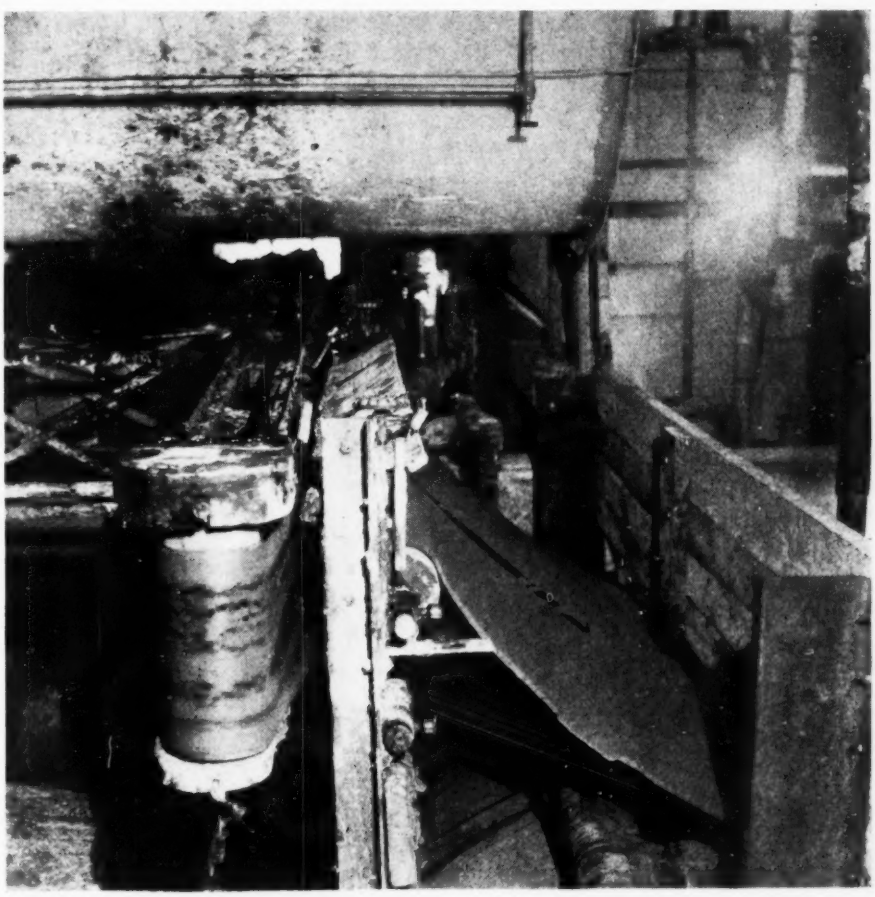


Fig. 6—Discharge of Sludge Cake from Filter

New Municipal Construction in 1930

Probable Construction Expenditures of Some of the Larger Cities for Municipal Improvements; Figures from Questionnaire Sent to City Engineers of 100 Cities of Over 30,000 Population

City and State	Probable Total Expenditures for Municipal Improvements	Water Works	Sewers	Paving	Bridges	Airports	Miscellaneous
ALABAMA							
Birmingham			$ 50,000	$1,000,000		$1,000,000	$4,500,000[1]
Montgomery	$ 750,000	$ 50,000	100,000				200,000
CALIFORNIA							
Berkeley			240,500	442,000			
Long Beach			450,000	2,106,255	$ 250,000		
Los Angeles			4,079,000	9,328,000	2,593,000		
Oakland	8,000,000	*	*	*	*	*	*
Pasadena	1,558,000	*	*	*	*	*	*
San Diego	4,963,000		645,000	4,203,000	115,000		
San Francisco		4,800,000	925,000	7,500,000	500,000	200,000	9,100,000[2]
Stockton							4,043,000
COLORADO							
Colorado Springs		70,000	60,000	134,000	10,000		
Pueblo	30,000	*	*	*	*	*	*
Denver	3,520,800	*	*	*	*	*	*
CONNECTICUT							
Hartford			50,000	761,675	1,900,000		
New Haven		500,000	75,000	100,000		235,000	
Stamford	500,000	*	*	*	*	*	*
DELAWARE							
Wilmington		1,500,000	180,000	250,000			
FLORIDA							
Jacksonville				300,000	12,000		40,000
Tampa		20,000	165,000	285,000		750,000	
ILLINOIS							
Danville	250,000	*	*	*	*	*	*
Elgin			15,000	280,000			
Oak Park		25,000	5,200	483,800			
Peoria		400,000	650,000		500,000		
Rockford	800,000	*	*	*	*	*	*
Springfield		6,000	4,800	482,600	10,000		200,000
IOWA							
Cedar Rapids		50,000	300,000	100,000			
Sioux City			145,000	256,000	60,000		
KANSAS							
Kansas City	$ 400,000	*	*	*	*	*	*
Wichita			$ 100,000	500,000	335,000	200,000	250,000
KENTUCKY							
Lexington			12,500	220,000	190,000		
Louisville		$ 250,000†	2,000,000	1,600,000			2,900,000[3]
LOUISIANA							
New Orleans			6,000,000[4]	4,000,000			10,250,000[5]
MARYLAND							
Baltimore		3,195,000	2,600,000	1,600,000	4,000,000	1,120,000	8,238,000[6]
MASSACHUSETTS							
Boston			1,500,000	2,000,000			
MICHIGAN							
Battle Creek		125,000	150,000	125,000			
Detroit			12,000,000	6,900,000	1,400,000		
Flint		1,000,000	800,000				350,000
Grand Rapids		200,000	150,000	800,000			850,000
Lansing			400,000		125,000		
Pontiac			500,000				
MINNESOTA							
Duluth	400,000	*	*	*	*	*	*
St. Paul		100,000	500,000	1,000,000	976,000	295,000	
MISSOURI							
St. Louis			4,050,000	5,650,000	500,000	300,000	1,500,000[8]
NEBRASKA							
Lincoln		250,000	25,000	340,000			50,000
Omaha			500,000	400,000			
NEW JERSEY							
East Orange	250,000	*	*	*	*	*	*
Newark		1,000,000		3,000,000[9]			4,000,000[10]
Trenton				500,000			
NEW YORK							
Buffalo			2,000,000	2,000,000	1,000,000		
Niagara Falls		50,000	250,000	200,000			
Rochester	2,000,000[11]	*	*	*	3,000,000	*	*
Yonkers	4,500,000[12]	*	*	*	*	*	*
NORTH CAROLINA							
Winston-Salem	1,500,000	*	*	*	*	*	*

*Expenditures not itemized. †By water company.

[1] Includes $3,000,000 for widening and deepening creeks and $1,500,000 for track elevation work (under construction). [2] $1,000,000 for incinerator $8,000,000 for public buildings, $100,000 for playgrounds. [3] $2,000,000 for grade elimination, $900,000 for school buildings. [4] For sewerage, water and drainage extensions. [5] $8,000,000 for lake front development and other levee work, $2,000,000 for public schools, $250,000 for docks. [6] Parks $178,000, conduits $300,000, schools $2,700,000, library $2,000,000, city hospitals $2,500,000. [7] Five miles of pavement. [8] For buildings. [9] Street paving, bridges and other related municipal work. [10] Subway work $1,000,000, Port Newark development and airport $3,000,000. [11] For sewers, paving, sidewalks, etc. [12] New building for health shelter, new school buildings, two combination fire and police stations and extensive paving and sewer construction. [13] Probable construction work $3,000,000; in addition $1,000,000 for street maintenance and minor reconstruction; bond issues as follows contemplated: For Municipal University, $427,000; park department, $145,000; playgrounds, $350,000; traffic lights, $200,000; hospital, $290,000; airport, $500,000. [14] Grade crossing elimination under direction of Dayton Union R. R. [15] Includes $1,000,000 city hospital. [16] Paving and sewering. [17] Union station, grade separations and track revisions. [18] Street and sewer construction. [19] Includes $150,000 garbage disposal plant, $750,000 grade crossing elimination and $300,000 park development. [20] Includes $2,250,000 for wharf construction. [21] Grade separation. [22] Gas and water. [23] Two miles of sewer, 3 miles of sidewalks, 2 miles of water mains. [25] Proposed 2.5 miles paving, 8 miles sidewalks, 5 miles of water mains, 5 miles of sewers.

City and State	Probable Total Expenditures for Municipal Improvements	Water Works	Sewers	Paving	Bridges	Airports	Miscellaneous
OHIO							
Akron		400,000	900,000	4,300,000	750,000	300,000	
Cincinnati	3,000,000[12]		500,000	*		*	*
Cleveland	8,000,000	*	*	*	*	*	*
Columbus		300,000	2,000,000	1,000,000			
Dayton			250,000	300,000			25,000,000[14]
Lakewood		29,500	40,850	157,000			1,147,000[15]
Lima			1,170,000	70,000			
Youngstown		225,000	630,000[16]	500,000	500,000		
OKLAHOMA							
Tulsa		400,000	1,000,000	1,450,000			1,500,000[17]
OREGON							
Portland		1,079,000	2,000,000[18]	190,000	255,000		
PENNSYLVANIA							
Erie		1,700,000	1,500,000	500,000			1,350,000[19]
Scranton	500,000	*	*	*	*	*	*
Wilkes-Barre	250,000	*	*	*	*	*	*
RHODE ISLAND							
Providence		800,000	1,842,000	1,750,000	648,000		250,000
SOUTH CAROLINA							
Columbia	100,000	*	*	*	*	*	*
TEXAS							
Beaumont		125,000	2,600,000	1,350,000		100,000	2,325,000[20]
El Paso			167,000	85,000		15,000	215,000
Ft. Worth			400,000	1,000,000	250,000		8,000,000[21]
VIRGINIA							
Lynchburg		30,750	43,800	75,600	5,000		
Norfolk				450,000	650,000		
Richmond		300,000[22]	500,000	700,000	1,500,000		700,000
WASHINGTON							
Spokane	450,000	*	*	*	*	50,000	*
WISCONSIN							
Green Bay[23]							
Kenosha[24]							
Madison		75,000	60,000	400,000			660,000

Effects of Cold Weather and Drought on British Water Supplies

Heavy frosts and a long extended drought caused much trouble for water works operators of Great Britain in 1929. In its annual review The Engineer summarizes these happenings as follows:

The year 1929 will long be remembered by many water works engineers as one of grave anxiety. There were, first of all, the severe frosts of the early months, which took their toll of burst water mains and pipes, besides introducing difficulties at filtration works. Then there was a drought which persisted, in some places, practically without break from early in the spring until the end of September, and finally, there were the excessive rains and floods of November and December. The number of burst water mains in the metropolitan area were, to all seeming, more frequent and serious than usual, through it was officially stated that the occurrences were neither extraordinarily numerous nor extraordinarily severe. Moreover, it was announced by the Works and Stores Committee of the Metropolitan Water Board, on which falls the duty of maintaining supplies in the London area, that though, undoubtedly, severe cold might and did occasion fractures of mains, it was not the only cause of such failures, and the committee pointed to the injuries brought about by the increased speed and weight of modern traffic as contributory factors. However, the committee decided to appoint a sub-committee specially to consider and report on the subject. The Council of the Institution of Water Engineers also appointed a strong committee of water works engineers to investigate the matter. This committee has not yet completed its inquiries.

Throughout the country the total number of burst service and other pipes must have been enormous. Approximate figures for two places, at any rate, are available. In Liverpool, it is said, there were some 29,000 burst pipes, and, as a consequence, nearly 130,000,000 gal. of water were lost. It is estimated that the total number of burst pipes in Burnley was 19,500 and that the loss occasioned by damage to meters, lavatory fittings, cylinders, etc., was some $200,000.

In some parts of the country the drought in the early part of the year was more pronounced than in others. Yorkshire began to suffer early. For the five months from February to June inclusive the precipitation was only just over 3.0 in., which is, of course, far below the average. Before the end of June, Barnsley, Batley, Bradford, Dewsbury, Doncaster, Halifax, Huddersfield, Leeds—to name just a few—had began to feel the effects, some of them severely. Bradford's supplies, it was reported, had not been so low since the early 'eighties. Halifax had more than 425,000,000 gal. less in its reservoirs than at the same time the year before. At Hull the water level in the wells from which its supplies are drawn was some 20 ft. below normal. Leeds had only 106 days' supply in store, as compared with 150 days in 1928 and 165 in 1927. Reports for other parts of the country showed the position to be quite as bad, if not worse. The East Cheshire authorities, for example, gave notice that if the drought did not break they would have to shut off supplies. In Edinburgh in the beginning of July the position was described as being "very serious." In many villages in Essex water had to be carted some distance and was sold at so much a bucket. At a village in Buckinghamshire as much as 4 ct. a gallon was being given a little later in the year. Similar instances might be adduced almost indefinitely. There is no doubt that much inconvenience was experienced throughout the land, and that over a wide area a great deal of hardship had to be undergone.

In the metropolitan area, though there was never any real shortage—thanks to the large volumes in the reservoirs, which were heavily drawn upon—restrictions prohibiting the use of water for garden watering through hoses and the cleaning of motor cars had to be imposed. It is probable, however, that that measure would not have been resorted to had consumers as a whole "played the game"—if we may be permitted to use such a colloquialism—when asked to be careful of the water, instead of—as they did—using an average of 30,000,000 gal.—or approximately 4 gal. a head—more per day than before the request was promulgated.

Another trouble, attributable to hot weather, was the excessive algal growths in reservoirs which was experienced in many places.

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How Silting Shortens the Lives of Some Reservoirs

That a certain reservoir would lose 95 per cent of its original capacity in 13 years, as a result of silting, would have seemed improbable 35 years ago, yet such is the fact. We refer to the 32,000 acre-foot reservoir at Austin, Texas, which was put into service in 1913 and was almost full of mud from the Colorado in 1926. A 49,300 acre-foot reservoir built at Austin in 1893 lost 48 per cent of its capacity in eight years, or at the rate of 6 per cent per annum; and the one built 20 years later lost capacity at the rate of 7.3 per cent per annum.

The Roosevelt reservoir on Salt River, in Arizona, lost 7 per cent of its capacity in the first 20 years (1906-1925), or only 0.35 per cent per annum. The Elephant Butte reservoir on the Rio Grande in New Mexico, lost 9 per cent of its capacity in 11 years (1915-1925), or at the rate of 0.8 per cent per annum. On the other hand, the McMillan reservoir on the Pecos River in New Mexico lost 42 per cent of its capacity in 10 years (1895-1904), or at the rate of 4.2 per cent per annum; and the Zuni reservoir on the Zuni River in New Mexico lost 95 per cent of its capacity in 22 years (1905-1927), or at the rate of 4.3 per cent per annum. The Buckhorn reservoir on Buckhorn Creek, Colorado, lost 47 per cent of its capacity in 18 years (1907-1925), or at the rate of 2.5 per cent per annum. These data on silting of reservoirs appeared in the November issue of *Water Works and Sewerage*, being abstracts of a discussion by R. L. Meeker.

If the life of these reservoirs is determined by the rate of silting, we have:

Reservoir	Life, years
Austin (Tex.)	14 to 17
Roosevelt (Ariz.)	286
Elephant Butte (N. M.)	125
McMillan (N. M.)	24
Zuni (N. M.)	23
Buckhorn (Colo.)	40

As we recall it, engineers have estimated that the proposed Boulder Dam reservoir on the Colorado River will silt up at the rate of only 1 per cent per annum. If so, its life will be 100 years, provided that it can not be economically de-silted. Suggestion has been made that silt can be sluiced out of such reservoirs, but how and at what cost? And during the sluicing process, what will become of the community that depends on the reservoir for its water supply? What will be the damage to lands in the lower reaches of a river, if great masses of silt are sluiced out?

In making estimates of the rate of silting up of reservoirs, bad errors are apt to occur, both because of great fluctuations in the percentages of silt carried in suspension and because of incorrect estimates of the material pushed along the bed of the stream. The eroding power of a stream increases much faster than does the volume of water that it delivers. Hence estimates of silt percentages based on subnormal flows may be very misleading. There enters also the problem of erosion and silt conveyance during very short periods of exceptionally heavy floods. There is almost nothing in print on this phase of the problem, and the meagreness of the published data doubtless reflects the ignorance that prevails on this subject even among well informed hydraulic engineers.

During more than a decade, rainfall has been subnormal in most of the drainage basins of our western streams, hence percentages of silt carried by most of those streams have been even more below normal than the runoff.

Many of the flood prevention dams that have been recently built and are under construction seem destined to have lives so short that the taxpayers will be badly "jarred" a few years hence unless engineers learn more about rates of silting than is now known and make clear to the taxpayers what life is to be expected for such dams.

Should Los Angeles Go to the Colorado River?

Should the Los Angeles district go to the Colorado River for water? Judging by the silence as to other sources of water supply, it might be inferred that there is none worthy of mention. The article by W. A. Gillette in this issue of *Water Works and Sewerage* makes it evident that the Mono Lake and Walker River basins on the east slope of the Sierra Nevadas have runoffs and reservoir sites adequate to take care of the probable increase of Los Angeles county population for the next 20 years. Los Angeles is now securing a large part of its water from the Owens River drainage basin just south of Mono Lake and is preparing to secure a small additional supply from the Mono Lake basin. Mr. Gillette quotes runoff statistics compiled by the State Engineer of California showing that the Owens River, Mono Lake and Walker River basins have a mean annual runoff of almost 1,500,000 acre-feet.

The city of Los Angeles at present consumes 120 gal. of water daily per person, and at that rate one annual acre-foot would supply 7.3 persons. Hence the 1,500,000 annual acre-feet would supply a city of about 11,000,000 people, if all of the water could be col-

lected and delivered. It is safe to estimate that 50 per cent can be delivered, which means that 5,500,000 people can be supplied from that source. Close to Los Angeles there are four river basins whose mean annual runoff is nearly 700,000 acre-feet, according to the State Engineer's estimates, namely, the basins of the Santa Ana, San Gabriel, Santa Clara and Los Angeles rivers. Adding their runoffs to that above given and assuming only 50 per cent delivered to consumers, there would be enough to supply an urban community of 8,000,000 people, which is a population more than threefold the present population of that district.

This being the case, why have the residents of that district been led to believe that it is imperative to go to the Colorado River, and to start going at once? Are the runoff data published by the State Engineer erroneous? If so, no public statement has been made to that effect. Will it cost more to conserve and use this California supply of water than to go to the Colorado River? If so, where are the published comparative estimates of cost that prove such a contention? Is Los Angeles growing so rapidly that it will be bigger than New York City and Philadelphia combined in ten years? One might think so, to read about the imperative need of water from the Colorado River.

It is not easy to put a finger upon the causes of so much silence as to California sources of water and so much talk about the Colorado River. We suggest the following as among the reasons.

Los Angeles has a municipally owned power and light plant in which $75,000,000 is invested. It has condemned and bought the electric distribution system of one power company and has just announced its desire to secure that of the other company. The heads of this power department see a big block of hydroelectric power available from the Colorado River project, and one securable at by-product prices if Los Angeles goes to the Colorado for water. They see the financing of this development by the U. S. Government, and they fear that the local voters will refuse to finance any further great expansion of the power department. Indeed, they are struggling right now to persuade the government not only to build the dam but to build the power plant at the dam, thus leaving only the transmission lines to be financed by the city of Los Angeles. This is, we believe, one reason why the citizens of Los Angeles have been told so little about California sources of water supply. And in this connection it should be noted that the water department is affiliated with the power department and that the power end wields the greater political power, or at least has the most active politicians on its salary list.

Two of the large dailies in Los Angeles are strong advocates of municipal power, and the owner of a third daily is said to be interested in arid lands that will be irrigable if the Colorado River project is put through. Hence their readers are not apt to be presented even with such information as we are giving in these columns.

In a previous editorial article we showed that about half the water that is to be brought from the Colorado to the Los Angeles district is to be used for irrigation, but that that fact is not made clear in the reports, because the wording is "Domestic, irrigation and other uses on balance of area." The "domestic" part of that item is negligible, and the irrigation item is almost the whole thing, but none but an engineer would be apt to know it. If the citizens of Los Angeles want to finance farmers to at least half the cost of the Colorado River project, well and good. But at least those citizens should be told that they are about to do that very thing if they approve the bond issue that will soon be presented to them.

The third reason—and perhaps the most important one—why the Colorado River project has been kept in the limelight to the complete exclusion of any alternative is this: It was originally believed that the federal government could be induced to build the Colorado River dam, and not place any of the burden of its cost upon those who would benefit by it. But this plan could not be put through congress, so a compromise plan was evolved. The federal government is to furnish the capital for the dam, but power is to be sold wholesale at prices that will pay interest on that capital and amortize the investment in 50 years. This sounds very nice, and would be very nice for Los Angeles, were there no economic alternative to going to the Colorado River; for it relieves Los Angeles of financing about half the entire cost of the project inclusive of the aqueduct. Having started along the Colorado River path to get more water, Los Angeles politicians, newspapers and even engineers are reluctant to seek another path.

But what about the board of consulting engineers that is now working on its report? The trouble there is that only two major questions have been put to that board, namely, where the dam should be built on the Colorado and what route the aqueduct should take. A question of far greater importance has not been put to them, namely: Is there any other source of water supply for Los Angeles that will be cheaper than the Colorado River project, at least for the next decade or two?

That question should be put to several distinct boards of consulting engineers selected by different public officials.

We recall the different reports on the Isthmian canal problem about 30 years ago. There were radical differences of opinion as between the Nicaragua and Panama routes; and when the latter was selected, there were equally radical differences of opinion as to whether it should be a sea-level or a lock canal. It was indeed fortunate that more than one board investigated that problem. Our belief is that every large project calls for several entirely independent investigations by the most competent engineers available. In the present case, a board of experienced electrical engineers should be employed, in addition to several boards of hydraulic engineers. It is our impression that as a power project the Colorado River project is an economic blunder of the first order. As an irrigation project it seems equally doubtful. As a city water supply project, the evidence is strongly against it. As a combination of all three projects, it may be a wise one; but the taxpayers are surely entitled to know to what extent they are going to be asked to finance (1) power, (2) irrigation and (3) city water plants.

More than 12 years ago the editor was a consulting engineer for two power companies in California, and thus came to have a fairly broad knowledge of water supply conditions in that state. Since then he has had no connection with those companies or any other

utility companies in California, and holds a brief for no one. He believes that a great economic mistake is pending in the Los Angeles district. He is not sure that it is to be a mistake, but he is sure that the public is entitled to have, and should insist upon, a much broader engineering investigation of all the problems above indicated.

"We Can't Foretell Weather from What Has Gone Before"

Commenting upon the exceptionally dry autumn on the Pacific coast, one of the forecasters for the Weather Bureau said: "We can't foretell weather from what has gone before." This is undoubtedly true as to our Weather Bureau methods, and it is all the more discouraging when it is remembered that the Bureau has been in existence more than 60 years and has expended many millions of dollars in gathering and publishing weather statistics. Almost the only use of rainfall records is in forecasting the amount of water that will probably be available. But in many large sections of the country it is not unusual to have rainfall of one year amount to less than one-third the rainfall of the previous year. The runoff variations are of course much greater than that.

The runoff produced by the San Gabriel River, California, during the dry period of 1893-1904 was less than 24 per cent of that during the wet period of 1883-93, the rainfall during those two periods averaging 11.3 and 20.3 in., respectively. Obviously it is of the utmost importance that some means of at least roughly forecasting such variations be devised. At the very time that Weather Bureau forecasters are admitting inability to use past rainfall records as a guide in forecasting future rainfall, hydraulic engineers in southern California are forecasting a decade of abnormally wet weather, and they are making this forecast with no slight degree of confidence because they have discovered that during the past half century wet and dry periods of about 11 years have alternated.

Starting with this fact, the editor has been able to show that the pines of Arizona and the sequoias of California disclose this same sort of alternation with remarkable regularity, for 500 years in the case of the pines and for 3,125 years in the case of the sequoias. In the November issue of *Water Works and Sewerage* and in the present issue, the data supporting this important conclusion are given. By establishing the law that alternate wet and dry cycles of 11.2 years exist in California and Arizona, it can no longer be said that past rainfall records are never of any assistance in forcasting future rainfall. Relatively few scientific prognostications can muster a greater probability in their support than is now demonstrable in forecasting a relatively wet decade in southern California. The discovery of this law is alone sufficient to warrant confidence that other similar rainfall laws are discoverable. In fact, it is not the first discovery of an important rainfall cycle, for it was shown many years ago that certain areas are unusually wet during sunspot maxima whereas others are unusually dry at those times. But sunspot maxima were not predictable with much accuracy, although they usually occurred at intervals of about 11 years. The editor has found that Jupiter tends to produce a sunspot peak every 11.2 years, but that the magnetic effects of Uranus or Neptune may override it, the former every 81.1 years, and the latter every 161.4 years.

As we view it, the main trouble with our Weather Bureau is that it is a fact gathering organization that lacks an adequate research department. Without the latter, the facts that it has gathered have been put to little practical use. The money has been well spent in gathering weather data. Indeed, more money could have been spent to advantage. We do not criticize the Bureau on that score. We criticize it for its failure to make full use of the facts that it has gathered. Perhaps it has been supposed that somehow or other rainfall laws would gradually disclose themselves as rainfall data become more numerous, but scientific discoveries seldom discover themselves in that fashion. On the contrary, discoveries usually occur as a result of framing hypotheses to explain facts, followed by rigorously testing each hypothesis by an appeal to facts. This calls for scientific imagination and a training in research methods, which the routine collector of statistics seldom possesses.

Intead of fostering every effort to solve the rainfall problems, the heads of our Weather Bureau have been accustomed to belittle the efforts of other men, and have even refused to publish certain theories because they conflicted with those held by themselves. Yet what fruit has any one of their own theories ever borne? Not a bit that is of assistance to any farmer or to any hydraulic engineer. A person would naturally think that the owner of so fruitless a tree would at least welcome suggestions from any source as to how it might be fructified.

While it is somewhat premature to say that a definite relation exists between Alaska rainfall and that farther south on the Pacific coast, the editor has found that an abnormally rainy month in Juneau or Sitka is often followed, two to three months later, by an abnormally rainy month in central and southern California. Washington and Oregon show a shorter lag. Obviously this can not be due to the length of time required for storms originating near the Aleutian "low" to reach southern points, for storms ordinarily travel at railway speed. The cause of this phenomenon will be discussed in a later article. In October rainfall was 17.7 in. at Sitka and 17.3 in. at Juneau, or 65 and 45 per cent in excess of the averages for those months. This will probably be followed by abnormal rainfall to the south.

It seems not unlikely that rainfall near the permanent "lows" of the Aleutian Islands and Iceland can be used to forecast rainfall several weeks later at other parts of the earth. This suggestion may enable some hydraulic engineer to discover means of forecasting rainfall in certain areas. And while such short-time forecasts are of minor value to hydraulic engineers, if substantially correct they would serve to throw light on the phenomenon of rainfall. Next to nothing of engineering value is to be found in meteorological text books and journals as to the causes of periodicity in rainfall.

H. P. Gillette

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1929 is now ancient history and to all the new friends we have made during the past year, together with all the old friends, we wish, for each and every one, the happiest and most prosperous year that one friend could wish for another.

Distributor News, along with all the other sections of our paper, has tried to serve you faithfully and well, and is looking forward with pleasure to continued cooperation. The manufacturers and distributors have come to realize, we believe, that there is a permanent place in the magazine for their news stories, and the other readers know that any information they may wish concerning the makers of the products which serve them is cheerfully furnished by this department.

Service Exchange has held out a helping hand all year to manufacturers seeking representatives, and distributors wishing to make connections for additional lines, and if our correspondence file is any measure of its success it has established a permanent place in Distributor News.

O. A. Stellar Made Ad Manager for McEverlast, Inc.

Announcement has been made by McEverlast, Inc., to the effect that Mr. O. A. Steller, formerly editor of "Concrete" magazine, has been appointed as advertising manager for their organization.

It is stated that the rapid growth of the McEverlast activities in all sections of the United States and foreign countries has made it necessary to enlarge the general staff and to center activities having to do with the distribution of information regarding the McEverlast products in the newly created publicity department. Mr. Steller's background of engineering, technical advertising and editorial experience starts him in his duties well equipped.

Previous to his connection with "Concrete," Mr. Steller was employed by the Portland Cement Association in the Chicago headquarters. He served this organization in both the road bureau and in the advertising and publications bureau. During the more than ten years with these two organizations, Mr. Steller has traveled extensively, visiting engineering projects and consulting with engineers in every section of the country. He has contributed engineering articles to a great many engineering magazines and has been active in engineering society attendance. He is now 39 years old.

Mr. Steller received his technical education at Marquette University and the University of Wisconsin, and secured his first practical experience in mining projects for the Peabody Coal Company, the engineering staffs of the Wisconsin Highway Commission, the Chicago, Milwaukee, St. Paul & Puget Sound Railway, the Chicago, North Shore & Milwaukee Electric Railway, and the U. S. Geological Survey.

In announcing the appointment of Mr. Steller, the McEverlast Company believe that they have strengthened the staff of their organization, which means another step forward in keeping with their progressive policies.

Announcement

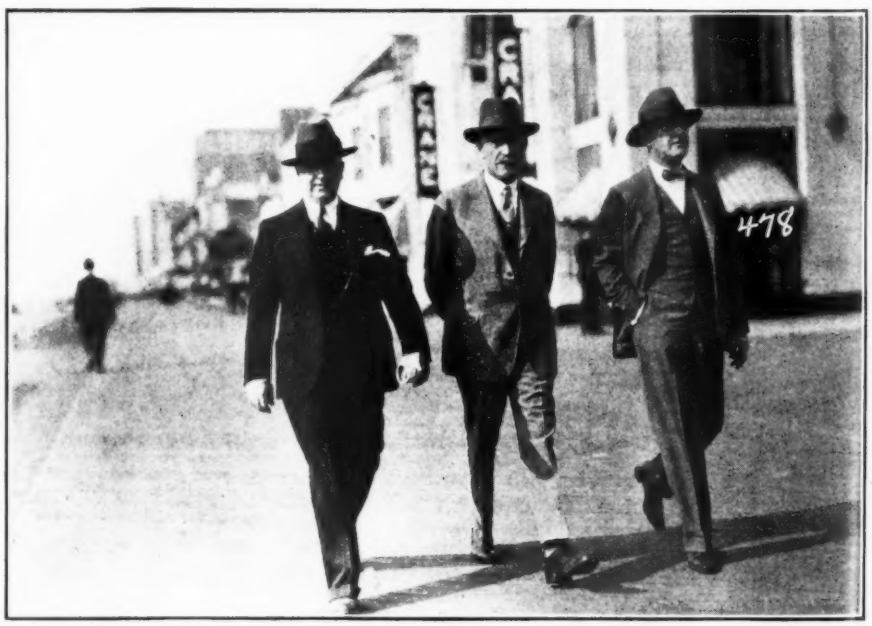
On and after Jan. 2, 1930, the interests of the Worthington Pump & Machinery Corporation in the California territory will be served through a local company, the Worthington Machinery Corporation of California, Ltd., with headquarters at Los Angeles and San Francisco.

Mr. H. D. Cornell, who has been president of the Worthington Machinery Corporation of Oklahoma, will be president of and direct the new corporation, moving to California for that purpose. Mr. George W. Hawkins, who has been the director of sales, will also go with Worthington-California, as vice-president.

The Worthington Machinery Corporation of California, Ltd., will take over the sales and engineering staff and the warehouse facilities of The Worthington Company, Incorporated, in California, and will hereafter handle all that territory.

This arrangement will enable the carrying of larger and more diversified stock of Worthington products and parts, and give more prompt service to the increasing number of Worthington friends and customers in California.

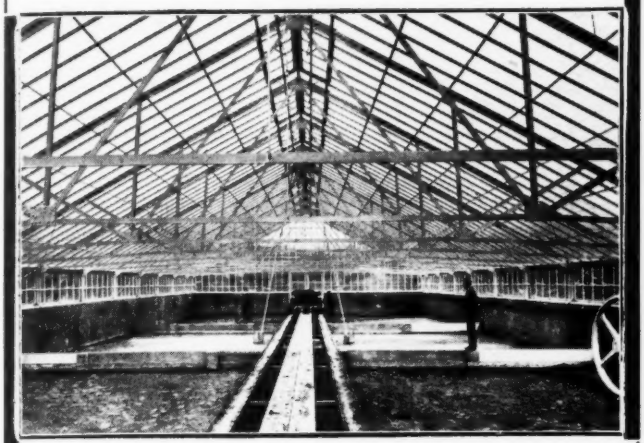
The above announcement was issued from the New York office of the Worthington Pump & Machinery Corporation, who believe that the new arrangement will be more acceptable to their patrons by making possible improved service.



On Their Way

The gentlemen strolling up the street are all officials of the Parsons Company, Newton, Iowa. They have recently been to Atlantic City, where the 1930 Road Show was held. Reading from left to right, they are: James McElroy, Director of Agencies; N. DeWind, vice-president, and W. E. Raftery, field sales manager. Mr. McElroy and Mr. Raftery make their headquarters in New York.

Sludge Bed Capacity TREBLED By Glass Enclosure



All-Weather Drying, with Double the Efficiency, Made Possible by King Sludge Bed Enclosures

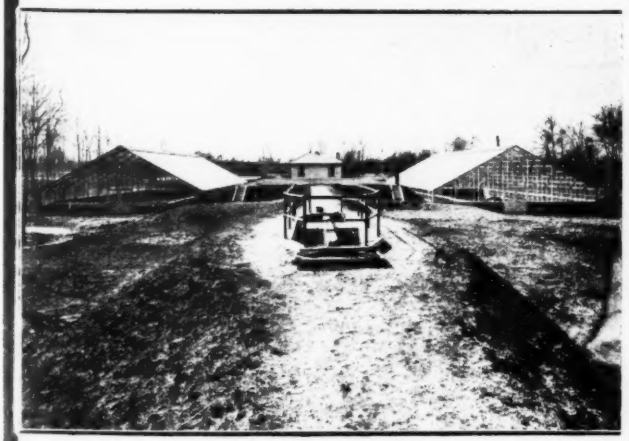
A necessary requirement of modern sewage disposal is rapid and uninterrupted sludge drying. This is effectively accomplished by King Sludge Bed Enclosures.

King Enclosures speed up the drying process and eliminate the serious seasonal aspects—the evaporation continues in all kinds of weather and throughout the winter. This practically trebles the capacity of the beds, making it practicable to serve three times the population with the same sludge-bed area which originally was open. Offensive odors are also controlled.

Let us furnish you with complete information. No obligation! Write today.

KING CONSTRUCTION COMPANY
533 Wheatfield St., North Tonawanda, N. Y.

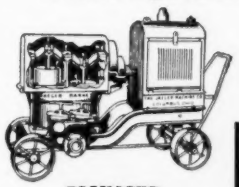
NEW YORK CITY PHILADELPHIA, PA. BOSTON, MASS.
SCRANTON, PA. TOLEDO, OHIO SCHENECTADY, N. Y.
BRIDEPORT, CONN.



Goodby Primers and Foot Valves!

Jaeger-Barnes SELF PRIMING Centrifugals *are Always Ready to Pump*

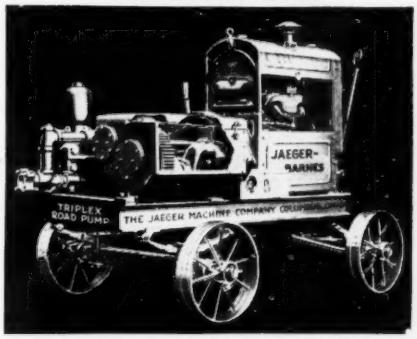
Get 3 times the capacity in one 100% automatic, continuous high vacuum pump. Sizes for any job...gasoline or electric. Puts other types out of date. Write for catalog and prices.



PLUNGER PUMPS

DIAPHRAGM PUMPS

TRIPLEX ROAD PUMPS



JAEGER MIXERS—PUMPS—HOISTS
Information Slip

THE JAEGER MACHINE CO., 224 Dublin Ave., Columbus, Ohio

Send catalog and prices on ☐ Pumps, ☐ Non-Tilt Mixers, ☐ Tilters, ☐ Timken Roller Hoists.

Name _____

Address _____

Neville & Cleary to Represent Simplex Valve & Meter

The Simplex Valve & Meter Company announces the appointment of Neville and Cleary, Inc., Candler Building, Atlanta, Ga., as its representative for the sales of its products in the territory south of Virginia, West Virginia and Kentucky line, and east of the Mississippi River.

Mr. T. J. Cleary, president, and Mr. W. D. Taulman, secretary-treasurer of the distributor organization, are well acquainted with the Simplex products, having had wide experience in central stations, industrial power and filter plants.

Mr. A. C. Hays will be in charge of the branch office at New Orleans, La.

Fred D. Holdsworth

Fred D. Holdsworth, Engineer in Charge of Air Compressor Design for the Sullivan Machinery Company at its Claremont, New Hampshire, plant from 1900 to 1928, died November 20th. Mr. Holdsworth was born in Wales, Mass., October 23, 1867. He graduated from the Worcester Polytechnic Institute in 1888, and after experience as Mechanical Engineer with the Rhode Island Locomotive Works and with the G. F. Blake Company, afterwards Blake & Knowles, he joined the Sullivan staff in 1900, remaining at Claremont as Mechanical Engineer in Charge of Air Compressor Design until his retirement, about a year ago.

The development of the Sullivan Angle Compound Air Compressor, Portable Gasoline Engine Driven Air Compressor, and Electric Motor Driven Mine Car Air Compressor took place under his direction.

He was awarded nearly fifty patents connected with the development of various Sullivan machines.

Mr. Holdsworth was a member of the American Society of Mechanical Engineers, and had been secretary of the Green Mountain Branch. He was active in civic affairs, serving on the Claremont school board, etc. Mrs. Holdsworth, a son and a married daughter survive him.

E. H. Pearson

The sudden death of Mr. E. H. Pearson on Dec. 7 came as a great shock not only to his associates in the Electric Machinery Manufacturing Company, but to his friends throughout the country. His loss is keenly felt.

Mr. Pearson was born in Malmo, Sweden, in 1893, where is spent his early life and received some of his technical education at the Institute of Technology in Malmo. On coming to Minneapolis, he started work with Crown Iron Works as an electrician, continuing his technical education at the Dunwoody Institute in Minneapolis.

In 1916, Mr. Pearson entered the employ of Electric Machinery Company as a service engineer for the Minneapolis district. In 1920 he was transferred to the New York office, where in the fall of 1921 he entered the sales organization of the company. In 1928 he became manager of the New York district office, which position he held at the time of his death.

He was a member of the American Society of Refrigeration Engineers, the American Society of Swedish Engineers of Brooklyn, N. Y., and the American Institute of Electrical Engineers.

Harry L. Monroe

Following a long illness, Harry L. Monroe, commercial vice-president of the General Electric Company, with headquarters at Chicago, died at Dallas Tex., on Jan. 7. Mr. Monroe completed 40 years of service with the company in September, 1928, six months after his election to the vice-presidency.

Mr. Monroe was born in Parkersburg, W. Va., in 1869. He entered the employ of the company in 1888, with the Thompson-Houston Company in Chicago. In 1890 he was transferred to the railway department, and in 1894 became a salesman operating out of the Dallas office of the General Electric Company. He was made manager of the railway department of the central district in 1905, and eight years later was named district sales manager, and later district manager of the central district, with offices in Chicago.

J. D. Capron Joins Glamorgan Company

Mr. J. D. Capron, for many years publicity manager of the United States Pipe & Foundry Company, Burlington, N. J., has resigned from that company to become general manager of the Glamorgan Pipe & Foundry Company, Lynchburg, Va., according to announcement recently given out. Mr. Capron will be succeeded as publicity manager by Mr. S. E. Linderman.

Mr. Capron is well known in the field of technical advertising and among the engineering profession, and has held prominent positions in the T. P. A.

Another Distributor for Trackson Company

The Valley Equipment Co., 2508-14 N. Broadway, St. Louis, Mo., has been appointed distributor for the Trackson lines of crawlers, loaders, shovels, cranes, hoists, bulldozers, hitches, etc., for the McCormick-Deering Tractor, manufactured by the Trackson Company, 500 Clinton St., Milwaukee, Wis. They will cover the St. Louis territory and will be able to fill orders and furnish repair parts promptly. Herman Ehlig is manager of the Valley Equipment Co.

House Magazines*

Editor's Note: This column is published every now and then. Many most attractive and interesting house magazines come to our desk from time to time, and we take this method of acknowledging them.

The U. S. Piper, published quarterly by The United States Pipe & Foundry Company of Burlington, N. J., has just completed its second volume, and the last issue received (December) is a most interesting little pamphlet. It contains an illustrated article on the Development of Distribution System of the Dallas City Water Works; an article on Bitumastic Lining for cast iron pipe; an editorial on Adequate Aqueducts, and other equally interesting material. Mr. Ralph M. Shaw, Jr., is the editor of this paper.

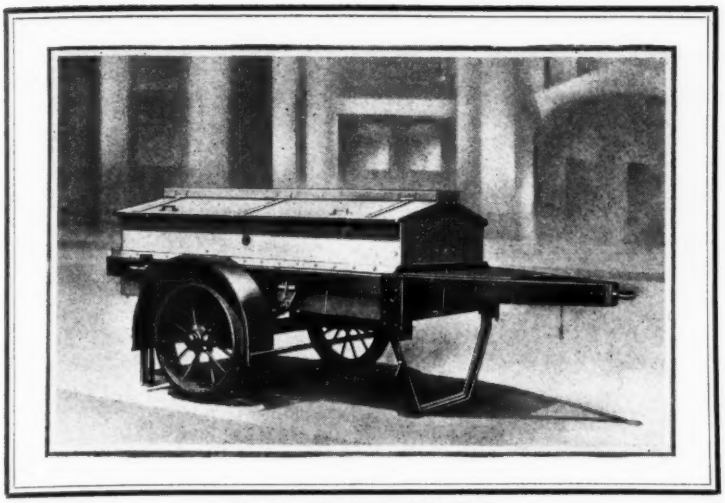
The Spiral Stripe is another attractive house organ issued by A. M. Byers Company, Pittsburgh. This little paper is filled with interesting and detailed descriptions of factories, schools, homes and other types of buildings where the wrought iron pipe of this manufacturer has been installed. Among the plants described are the Rayon Mills of the American Chatillon Corporation, Rome, Ga.; Columbia High School at Maplewood, N. J.; Canfield Oil Company, Coraopolis, Pa.; John Dieckmann's Greenhouses at Wheeling, W. Va., and many others.

The Amsco Bulletin, issued by the American Manganese Steel Company, Chicago Heights, is filled with illustrated details of Fahralloy, a name given to a series of chromium and nickel alloys, each made for a particular condition requiring heat and corrosion resistance.

Bores & Strokes for December comes from Schramm, Inc., West Chester, Pa., bearing the Season's Greetings and many interesting notes and pictures of the Schramm compressor "on the job." H. W. Moore Equipment Co. of Denver are featured in this number as distributors of Schramm."

The Monarch Operator, the official organ of the Monarch Operators' Club, the purpose of it being to arouse enthusiasm and maintain contacts between Monarch tractor operators throughout the world. Members of the club, who must be Monarch operators vouched for by dealers and distributors, and holding membership cards, are contributing writers for the magazine, furnishing stories and pictures of actual experiences in the field. A prize picture contest is now underway for the best pictures of Monarch tractors in action. All Monarch tractor operators the world over are invited to join this club. Information may be secured from dealers or by writing the Tractor Division of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

*Manufacturers named will be pleased to send above mentioned publications to readers upon request.



THE HEAVY DUTY TOOL BOX

TOOL BOXES
Made of Steel

LITTLEFORD TOOL BOXES are not only made of steel mounted on strong running gear—they are made for accommodation of tools and equipment used by maintenance departments. In three styles—Heavy Duty, Utility (both portable), and Stationary. There is a size and price for you. Write for complete information. You'll be under no obligation.

Littleford Compound Furnaces are made in 25 and 50 gallon sizes, both oil and wood burning types.

STEEL BOXES FOR EVERY PURPOSE — LB — LITTLEFORD BROS. CINCINNATI, OHIO

LITTLEFORD
ALL-STEEL
TOOL BOXES

LITTLEFORD BROS. 454 E. PEARL ST. CINCINNATI, O.

GOLDEN-ANDERSON

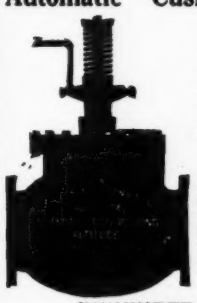
GOLDEN-ANDERSON
Patent Automatic Cushioned Controlling Float Valves

Adapted to automatically maintain a uniform water level in feed-water heaters, tanks, reservoirs, and pans. Very sensitive.

Operating on ½-in. to ¾-in. variation. No exhaust or expensive water waste. Can be furnished for hot or cold initial water supply. Reliable and dependable under varying pressure.

Sizes ½ in. to 24 in.

Automatic "Cushioned" Controlling Altitude Valves
Cushion All Water Surges



Automatically maintains a constant stage of water in reservoirs, tanks and standpipes. They do away with the annoyances of Freezing Valves and Float fixtures inside of the Tanks or Floats and Fixtures outside of Tanks. "Three Ways of Closing These Valves."

1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By Hand.

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe.

The double cushion effect of air and water eliminates water hammer. There are no dangerous surges to burst water mains. **Write for details.**

REMEMBER Valves cushioned at all times by air and water. No water hammer or bursting mains.

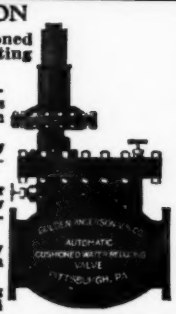
"Made with stop starter attachment for centrifugal pumps."

Golden-Anderson Valve Specialty Co.
1385 Fulton Bldg., Pittsburgh, Pa.

GOLDEN-ANDERSON
Patent Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-in.

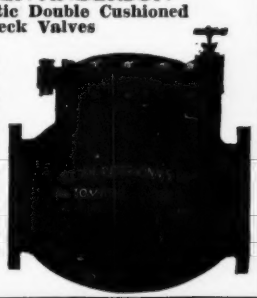
GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Pressure Regulating Valves



1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

GOLDEN-ANDERSON
Pat. Automatic Double Cushioned Check Valves

1. Especially adapted for Water Service.
2. For High or Low Pressure.
3. Thoroughly Cushioned. No Chattering, Hammering or Sticking.
4. Globe or Angle Patterns up to 24 in.
5. Especially adapted for hydraulic elevator service.



GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipe, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle—Most Satisfactory Float Valves known.
4. No Metal-to-Metal Seats—No Water Hammer or Shock.
5. Cushioned by Air and Water.

Sizes ¼" to 24".

National Equipment Becomes Operating Organization

Announcement has been made that on Jan. 1, 1930, the National Equipment Corporation became an operating company. This organization is a consolidation of the Koehring and T. L. Smith Companies of Milwaukee, the Insley Manufacturing Company of Indianapolis, The Parsons Company of Newton, Ia., and the Kwik-Mix Concrete Mixer Company of Port Washington, Wis.

Headquarters of the corporation are located at 31st St. and Concordia Ave., Milwaukee. Mr. Philip A. Koehring is president and general manager.

Sales, service, advertising and accounting departments have been centralized, with a view to more efficient service to customers, as well as effecting economies in operation and overhead.

Mr. R. E. Brooks, for a number of years engaged in the equipment business in New York, was recently elected vice-president and will be in charge of sales.

The officers of the National Equipment Corporation are: P. A. Koehring, president and treasurer; W. H. Insley, vice-president; H. E. Smith, vice-president; H. C. McCardell, vice-president; W. J. Koehring, vice-president; R. E. Brook, vice-president; W. J. Zimmers, secretary; G. E. Long, comptroller; and C. A. Koehring, assistant treasurer.

E. L. Carpenter Appointed to Hoover Survey Conference

Announcement has been made of the appointment of E. L. Carpenter, president of the National Lumber Manufacturers' Association, as a member of the executive committee to carry out the business stabilization projects contemplated by President Hoover.

Others who will serve on this committee are:

Owen D. Young, chairman of the board of the General Electric Company; Myron C. Taylor, chairman of the finance committee of the United States Steel Corporation; Thomas W. Lamont, of J. P. Morgan & Company; Paul Shoup, president of the Southern Pacific Company; and Clarence M. Woolley, chairman of the American Radiator Company.

Henry M. Robinson, president of the Los Angeles First National Trust & Savings Bank; Walter C. Teagle, president of the Standard Oil Company of New Jersey; James Simpson, president of Marshall Field & Company, Chicago; C. F. Kelley, president, Anaconda Copper Mining Company; Pierre S. duPont, Wilmington, Del.; Lewis E. Pierson, Irving Trust Company, New York City; George Horace Lorimer, editor, Philadelphia; Walter S. Gifford, president, American Telephone and Telegraph Company; Alvin Macauley, president, National Automobile Chamber of Commerce, Detroit.

E. L. Carpenter, of Shevlin, Carpenter, Clark Company, Minneapolis, Minn., President of the National Lumber Manufacturers' Association, Who Has Been Named to the Executive Committee of President Hoover's National Business Survery Conference

John G. Lonsdale, president, American Bankers' Association, St. Louis; Steuart C. Cramer, director, Cotton Textile Institute, Cramerton, N. Car.; Charles Cheney, president, National Industrial Conference Board, Manchester, Conn.; Silas H. Strawn, chairman of Montgomery Ward & Company, Chicago; and Harry Chandler, publisher, Los Angeles.

Charles Piez Elected President A. S. M. E.

Charles Piez, chairman of the board of Link-Belt Company, was made president of the American Society of Mechanical Engineers, held in New York City recently. He is widely known as an engineer, manufacturer and executive.

Mr. Piez was born in Germany in 1866, of naturalized American parents. He received his technical education as a mining engineer at the School of Mines, Columbia University, his own earnings going to pay for his education. After graduation he entered the employ of the Link-Belt Engineering Company at Philadelphia as an engineer draftsman at $65 a month. Seventeen years later he was made president of the Link-Belt Company, a consolidation of the Link-Belt Machinery (Chicago), the Ewart Manufacturing Company (Indianapolis), and the Link-Belt Engineering Company (Philadelphia). This organization now has twelve factories in eight cities, and sales offices throughout the world.

Largely as a result of his fame as an organizer and manager of industry, Mr. Piez was selected in November, 1917, to be vice-president and general manager of the United States Shipping Board Emergency Fleet Corporation, to carry out the nation's shipbuilding program. In this undertaking he was associated with Mr. Charles M. Schwab, whom he later succeeded as director general. He had control over 600,000 persons employed in the shipyards and fabricating plants, and industries furnishing supplies to the yards, and directed the expenditure of three billion dollars.

At the close of the war, Mr. Piez returned to his private business, continuing as president of the Link-Belt Company until 1924, when he became chairman of its board of directors.

In addition to being president of the Society of Mechanical Engineers, he is president of the Commercial Club of Chicago; a director of the Foreman State National Bank of Chicago and the Drexel State Bank of Chicago; director of the Illinois Bell Telephone Company; a member of the executive committee of the Museum of Science and Industry, founded by Julius Rosenwald, and a member of the American Institute of Mining and Metallurgical Engineers, Society of Naval Architects and Marine Engineers, Western Society of Engineers and Engineers of Northeastern Pennsylvania.

Mr. Piez was president of the Illinois Manufacturers' Association in 1911-1913, and again in 1924-25. As a member of the commission that drew the state factory act he was instrumental in framing much of the labor legislation in the State of Illinois. He was chairman of the Workmen's Compensation Commission, and a member of the State Arbitration Board.

Charles M. Nuckolls Joins H. D. Conkey & Company

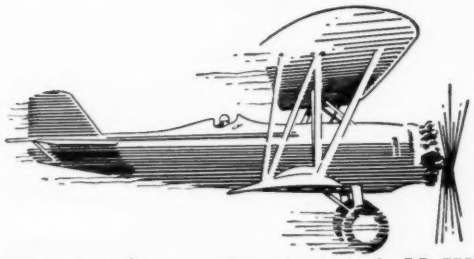
According to announcement Charles M. Nuckolls, formerly with the International Harvester Company, Chicago, has accepted a position with H. D. Conkey & Company of Mendota, Illinois.

Prior to his connection with the International Harvester Company, Mr. Nuckolls was associated with the Whiting Corporation, Harvey, Illinois, and the Shaw Crane Works, Muskegon, Michigan.

Wanted Sales Engineer

A contractors' equipment sales engineer to travel throughout the United States, under 40 years of age and, if possible, with an acquaintance among distributors, is being sought by manufacturer. Adequate salary and expenses plus commission is offered. Send your application to Distributor News, stating age, education, experience and past earnings. Same will be forwarded to manufacturer and will be held confidential.

McWane Pipe for the Air Mail!



Perhaps you have not connected McWANE Cast Iron Pipe with the Air Mail—except that both are leaders in progress! . . . But air mail requires air ports. And air ports require the best and most reliable of construction materials. Which naturally meant McWANE Precalked Joint Pipe at this Oregon air port.

WHY McWANE PIPE SUCCEEDS

50% greater tensile strength—30% greater transverse strength than A.W.W.A. specifications ask. Sand cast, yet modern weights. B. & S. type. Standard lengths. Precalked Joint Fittings, too. Write for literature.

WRITE FOR ILLUSTRATED LITERATURE

McWANE CAST IRON PIPE

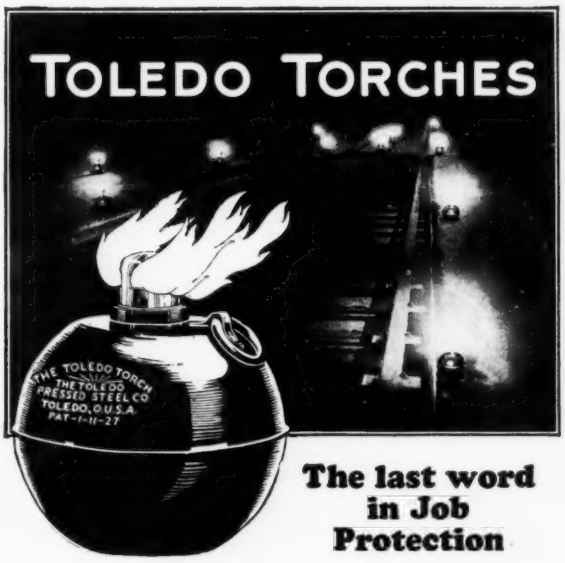
McWANE CAST IRON PIPE COMPANY BIRMINGHAM, ALA.

PACIFIC STATES CAST IRON PIPE COMPANY PROVO, UTAH.

SALES OFFICES IN PRINCIPAL CITIES

Don't Blame Accidents on Bad Luck

You don't have to have them!



The last word in Job Protection

There is no longer any excuse for accidents on open construction work. Toledo Torches not only protect *better* than all other safety lights—they also do it more *cheaply.* Their universal use is the best proof that they fill the bill. You can't go wrong with Toledo Torches, equipped with the *patented* Economy Burner. They are guaranteed. Call or write your dealer now, or write us.

The Toledo Pressed Steel Co.

Toledo, Ohio

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Equipment distributor in Pacific Northwest desires line of road building equipment, structural building equipment, dump bodies and truck hoists.

Distributors of contractors' and builders' machinery and equipment are seeking line of road forms, road finishers, batcher plants, clamshell buckets and drag line buckets, for northern California terirtory. Now stocking equipment for several well known machinery manufacturers.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Road machinery distributor would like to secure exclusive sales rights for state of Mississippi for line of automatic or self-loading wheeled scraper.

A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Manufacturers' representatives located in New York would like to add line of heavy contractors' equipment of established reputation, other than the lines now handled by them. They would like exclusive sales rights for such equipment.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Equipment distributor located in Michigan desires to add two or three good lines to serve territory in southeastern part of state.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Distributor covering New Jersey and New York territory would like to secure a line of street markers or other traffic equipment on exclusive basis.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

Machinery distributor established in Porto Rico and Santo Domingo would be pleased to make arrangements to take on new lines in these territories.

Machinery company in the east is interested in representing established lines of road machinery, with the exception of graders.

Distributor thoroughly familiar with bituminous materials and equipment for handling, wishes to add to present lines. Covers Wisconsin and Illinois territory.

Representatives Wanted

Manufacturer of truck, adapted to many uses, has attractive territory open in Missouri, Kentucky, Kansas, Nebraska and several southern states.

Manufacturer of hoisting machinery and air compressors has open territory in New York and New England states for aggressive distributor.

Manufacturer of excavating equipment desires to build up distribution organization throughout the country.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Attractive territory available for experienced men to handle contractors' labor-saving equipment by old established company. Equipment backed by national advertising.

A manufacturer of paving expansion joints is looking for distributors for northern California territory.

Manufacturer of metal lath, corner beads, channels and reinforcing mesh desires to secure distributors for products in the southwest and middlewest.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Manufacturer of mechanical spreaders for cover material desires representation by organizations covering entire states. Several desirable states are still open. Number of inquiries now on hand for spreaders require immediate follow up.

Manufacturer of automatic dipper trip, adapted to any type shovel (steam, gasoline, diesel, electric, etc.); with rapidly growing business, is seeking additional representatives.

Manufacturer of complete line of construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Manufacturer of rotary pump, especially designed for road construction work, has proposition for reliable distribution houses.

Good side-line offered to manufacturers' representatives covering municipalities and public institutions.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.

Manufacturer of air compressors and contractors tools has number of desirable territories open. Full co-operation will be extended to distributors.